AN INVENTORY AND ANALYSIS OF HIGHER EDUCATION FACILITIES IN THE COMMONWEALTH OF MASSACHUSETTS

FINAL REPORT TO THE MASSACHUSETTS HIGHER EDUCATION FACILITIES COMMISSION - JULY, 1970

FACILITIES INVENTORY PROJECT - CAMBRIDGE, MASS.

DONALD M. LEVINE, PROJECT DIRECTOR

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EDWARD F. BOCKO, SR., EXECUTIVE DIRECTOR

THIS PROJECT WAS FUNDED THROUGH THE HIGHER EDUCATION FACILITIES ACT OF 1963, COMPREHENSIVE FACILITIES PLANNING PROGRAM, UNITED STATES OFFICE OF EDUCATION

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PREFACE

In authorizing the Facilities Inventory Project, The Massachusetts Higher Education Facilities Commission recognized an increasing need for more comprehensive data concerning the institutions of higher education in the Commonwealth. This recognition coincided with a national effort to produce a better data base to be used by educational planners. The project in Massachusetts was especially difficult. There were more than ninety public and private institutions ranging in size from some of the largest in the country, offering a wide range of graduate programs, to some very small and very specialized professional institutions. Collecting the data and monitoring its accuracy required many hours of work. At the conclusion of the study, information about twenty-five-hundred buildings had been coded on one-hundred-seventy-five-thousand punched cards and entered in the data file.

A project of this scope could not have been completed without the assistance and genuine interest of a number of people. While it is impossible to mention individually the efforts of some ninety institutions and fifty staff associates participating in the project, we would like to acknowledge some special contributions.

Mr. Edward F. Bocko, Sr., Executive Director of the Massachusetts Higher Education Facilities Commission, maintained a close relationship with our project staff. His advice considerably expedited our work. His assistants, Mrs. Florence Coombs and Miss Jo-Ann DeStefano, also were very helpful in the administrative processing of the project. In addition,

a Committee of Advisory Consultants assisted the project. Harold L. Goyette, Planning Officer, Harvard University; H. Jackson Littlefield, Jr., Planning Officer, University of Massachusetts; and O. Robert Simha, Planning Officer, Massachusetts Institute of Technology, provided advice on project policy. Mr. Goyette, Chairman of the Committee, frequently met with us to discuss the progress and management of the project and the nature of its output. Mr. Littlefield took an active interest in our work and aided us in analyzing the data. It should be noted that this Advisory Committee generously donated its time to the project. We also received valuable information from the Office of Planning in Higher Education of the New York State Education Department. Mr. John G. Roenigk of that agency's Higher Education Comprehensive Planning Program advised us about the early implementation of the project.

Much of the administrative work was the responsibility first of John C. O'Conor and then of Gerald Blake and Julia Chang. They greatly helped to organize the collection of data and the evaluation of its usability. The analysis of the data owes much to Richard P. Junghans, Harvard University, who made large contributions to formulating our correlations and matrices. Mr. Junghans was assisted in these analyses by Jack Lieberman. Mr. Bro Uttal helped to prepare the Final Report and rendered editorial advice throughout the project. Computer programming was accomplished with the help of Cambridge Computer Associates, who also documented the "Description of the FIPS Computer System." Our punching and machine time requirements were met

by Autocom, Inc., AVCO Corporation, and Philip Hankins, Inc. Finally, much of our manuscript was typed by Miss Linda Shane.

While I assume full responsibility for the results of the project, whatever success the construction of this data base and the resulting projections may have is due to the combined efforts of the Facilities Inventory Project Staff, Advisers, and Consultants.

Cambridge, Massachusetts
July 7, 1970

Donald M. Levine

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CHAPTER I INTRODUCTION

This report marks the first stage of a two part study of higher education in the Commonwealth of Massachusetts. The overall goal of the study is to improve our judgment and decisions concerning the use of public and private educational resources. The report should facilitate evaluating how well current resources serve the demands placed on them and predicting how these resources must be increased and reallocated to meet future needs. But such inferences rely on a comprehensive description of existing resources--the facilities inventory.

Thus, for a moment, we are dealing mainly with variables of supply and distribution; only in a limited way do we touch on problems of demand.[1/] Examining such variables can be of immense value--if we ask the right questions of our data. The first step in doing this has been to order our description of physical facilities in terms of five basic questions:

1. What is the size of the particular educational facility?
2. What is its function?
3. What is its physical construction or design characteristics?
4. What are the dates of its construction or rehabilitation?

1/ We have integrated some basic enrollment figures with the facilities data.

5. How much did it cost, how was it payed for, and how much is it worth today?

We have answered these questions for virtually every building used for educational purposes in the Commonwealth of Massachusetts. Then we went on to ask further, more complex questions about relationships and trends among these variables. This analysis can be directly relevant for various members of a planning team.

For instance:

A. The economic planner at federal, state, or local levels may want to see how much has been invested in specific types of facilities during the last thirty years. He can find trends in different types of investment, changes in utilization, and depreciation of value. He may derive a more objective view of the consequences of different levels and kinds of investment.

B. The designer may focus on trends in construction. In conjunction with his own criteria he can, for example, assess the relative value of renewal versus new construction and present his clients with a clear set of alternatives given their specific problems.

C. The local university administrator can look at the distribution of resources within his school and between his and comparable institutions. He can use this information to evaluate requests from departments; to plan to emulate or avoid trends in other institutions; to communicate in general, comprehensive terms with potential sources of funding.

It is possible for the facilities inventory to have a rather immediate general effect on educational resource planning. Because it is a standardization system, it can facilitate communication among public and private, state and federal planning officers. To the degree that conflicts in planning result from limited experience and narrow perspective, they can be reduced through free access to objective data. In conjunction with the forthcoming analysis of space needs and utilization, the inventory may become part of what the National

Science Foundation has called a "national open-ended, compatible total information system:"

> "Recognition should be given to the fact that the information systems of all levels of education must be capable of being intermeshed and that these systems should fit into the totality of the scientofic community and other comparable communities since common data on these groups are needed for many purposes. 2/

Such comprehensive systems permit simultaneous planning for facilities and other major areas of educational resources. These include curriculum development, faculty recruitment and support, and student activities.

Inevitably there is fear that this sort of large scale planning inescapably leads to centralized, overbureaucratic control of education. This is not necessarily the case. Local planning itself is an increasingly complex and difficult procedure. Communities need access to information in order to maintain or increase their autonomy. The question of decentralization is not decided by the introduction of comprehensive systems. It simply is posed on a more sophisticated level.

It should be clear that the value of the inventory goes beyond the vast sum of information it contains. It is a system for organizing information and a tool for using it. We have designed it to grow - to receive and to classify new data. We have analyzed this data so that it is relevant and useful for a variety of planning needs and perspectives. Yet our analysis is simply a model, one set of inferences that can be drawn from the data. Other trends will be revealed to those who think of and ask the right questions.

2/ Systems for Measuring and Reporting the Resources and Activities of Colleges and Universities, NSF 67-15, p. 3

CHAPTER II HISTORY AND DESCRIPTION OF THE STUDY

The Higher Education Facilities Act of 1963 is a landmark in federal legislation for education. It reflects two convictions of the Congress: that higher education is basic to the welfare both of young Americans and of the entire nation, and that institutions of higher education need federal assistance to provide all the services their goals require.

To help in providing necessary physical facilities, the federal government first had to define facility needs. Therefore an essential step was to assemble a complete inventory of existing college and university facilities throughout the nation.

In 1966, the United States Office of Education initiated a national study of higher educational facilities on a state by state basis. The Massachusetts Higher Educational Facilities Commission conducted that study for the Commonwealth of Massachusetts. A joint advisory committee was established to guide planning teams, to reflect diverse institutional needs, and to recommend appropriate actions and decisions to the Higher Education Facilities Commission.

To complete its inventory, the Massachusetts Facilities Inventory Project followed manuals and guidelines issued by the United States

Office of Education. The most important of these was the 1967 U. S. O. E. publication entitled Facilities Classification and Inventory Procedures for Institutions and State Agencies. This manual described and defined the information the Office of Education wanted to have included in each state's physical facilities inventory. As the 1967 manual makes clear, the goal of the study was to obtain as much information as possible about all buildings and all rooms of every college and university in each state.

Data concerning buildings included:

Building Name

Building Number

Gross Square Feet

Ownership

Date of Initial Occupancy

Estimated Value of Building

Condition of Building

Source of Funds

Actual Capital Investment

Assignable Square Feet

Custodial S uare Feet

Circulation Square Feet

Mechanical Square Feet

Construction Square Feet

Furnishing Cost

Type of Cooling System

Type of Construction

Degree of Graduate Program

Location

Number of Floors

Year Renovated

Year Constructed

Year to be Demolished

Fall Out Shelter Rating

The data concerning rooms within each building included:

Building Number

Room Number

Subject Type

Room Type

Net Assignable Square Feet

Number of Stations

Percent Used for Research

The manual fully described each data classification and suggested efficient methods of collecting the necessary information.

Early in 1968, the Massachusetts Higher Education Facilities Commission contacted ninety-six college and university presidents

throughout the state to inform them of the upcoming study, and asked each of them to select an institutional representative to work closely with the Facilities Inventory Project Staff. To acquaint these newly appointed representatives with the methods and goals of the study and with the project staff, a series of pre-study meetings took place at selected institutions throughout the state. These meetings introduced the study, explained its history and goals, and stressed the importance of accurate data collection. Because this was to be the first study of its kind ever done in Massachusetts, many questions arose concerning problems like data collection time limits, manpower, and 'exception to the rule' cases. For the most part, explanation and interpretation of project guidelines solved these problems.

Soon after the meetings, each college representative received the forms and the manual necessary to completing his inventory. These materials, developed by the Facilities Inventory Project Staff and its advisors, followed the specifications of the U. S. Office of Education's Facilities Classification and Inventory Procedures for Institutions and Agencies. Two forms were used in the study. The first was a Building Characteristics Form which included all the information required by the U. S. Office of Education. The second was a Room by Room Analysis Form that also fulfilled USOE requirements. The Facilities Inventory Project Manual contained the classifications, descriptions, definitions and procedures that appeared in the USOE publication.

Because this study was the first attempt to measure and categorize all the existing physical facilities of the participating colleges and universities, unforseen problems arose for both the individual institutions and the Higher Education Facilities Commission. It became evident that many institutions were too understaffed to collect huge amounts of data within the inventory's time period. Assistance was required to prevent many institutions from dropping out of the study. Thus in February, 1969, a staff of Research Assistants was formed to help institutions collect data. The staff varied in size from 10 to 20 persons working throughout the state. In some cases, it had only to transcribe measurements from institutional blueprints and assign appropriate Subject and Room Codes. In other cases, the Facilities Staff had to measure by hand, a task the institutional staff never may have had time to do. An additional advantage of using the staff was the consistency with which it reported data. Individual institutional problems were dealt with uniformly, which eliminated the inconsistencies that might have arisen if each institution had used its own interpretation.

Soon after data cleaning, which entailed correcting all inconsistencies in reporting, keypunch errors, and programming inefficiencies, the data was ready for distribution to the participating colleges. and universities. In November, 1969, they received the first section of complete Facilities Inventory Project data - a printout necessary to complete the 1969 Higher

Education General Information Survey (H. E. G. I. S.) form.

The remaining sections - a complete institutional listing, and a correlation-matrix section - were distributed at the state-wide meetings held to introduce the Space Utilization Study. These meetings were held at the University of Massachusetts at Amherst, at Harvard University, and at the Massachusetts Institute of Technology, in December 1969 for the benefit of insittutional representatives, selected by college presidents. At these meetings, the remaining Facilities Inventory Project data was distributed and discussed in detail. The college representatives learned what types of data appeared in the print-out and came to see how useful such data could be to the institutional planning officer.

CHAPTER III DESCRIPTION OF COMPUTER OUTPUT DATA

This chapter describes the summary listings, matrices, and correlations. Each participating institution received a listing of input data (the Data Edit and Validation Report) and a set of derived data materials generated by the Listing and Matrix programs (see Appendix A). These programs also produced outputs on the State level, the summaries of which more than duplicate those available on the Campus level. In addition the plot program produced a series of Statewide correlations.

Campus Level - Part I: Data Edit and Validation Report

Part I contains all inputs used to generate campus level matrices and statewide matrices and correlations. Section A of Part I presents information for each building of participating institutions, and Section B displays data for each room within the building.

The institution's number and name appear on the first line of Section A. This identification is followed on the same line by an indication of the type of school according to two federal codes: from I through V to show the level of training provided and from A through K to show the type of program offered. The last datum on this first line shows the number of full time graduate and undergraduate students enrolled at the institution in question as of Fall, 1968.

The second line contains the number and name of the building for which the succeeding data have been collected.

The third line contains six major headings under which appear various date relating to the building identified on the second line. Four kinds of information are shown under the first heading, functions: ownership, degree to which the building is used for graduate programs, type of professional school that the building serves (if any), and the building's location.

Under history, the second heading, appear four other kinds of information: the year in which the building first was occupied, the year in which it was constructed, the year of its most recent

rehabilitation and/or modernization, and the year in which it is scheduled for demolition (if any). Five kinds of data appear under design; they are type of construction, number of floors, condition, status of fallout shelter according to the National Shelter Survey, and percentage of building that is air-cooled by means other than fans.

The last three major headings include information about costs, area, and funding. Under investment appear the cost of the building (including all investment after construction), the cost of equipment contained in the building, and the building's current estimated insurable value. The appropriate figure is shown beneath the gross square feet heading. Finally, the sources of funding for construction and the amount of funding from each source appear under source of funds.

Printed directly below Section A, Section B is an extensive room-by-room facilities inventory that lists information for every kind of room, including non-assignable areas like halls and spaces required by the building's frame. All the information for each room appears on one line and is divided by six headings. An unique number, supplied by the Facilities Inventory Project when necessary, is printed under room number. Three data appear beneath organizational unit - the institution's name for the unit (Business Office, French Dept., Dormitory, etc.), the institution's code for that unit or room (if any), and the organizational unit-subject field code.

Two kinds of information are listed beneath room type. They

are the institution's designation for that room type (dorm room, laboratory, office, etc.) and the room type according to codes for either assignable or non-assignable area. The appropriate number appears under number of stations (seats, beds, carrels, etc.), net assignable square feet (NASF), and percentage of research to which the room is devoted.

Below the last line, which corresponds to the last room in the inventory of a particular building, is printed a figure that represents total assignable area for the building.

Both Sections of Part I are continued to cover every one of the institution's buildings. Beneath the complete data for the last building a figure is listed for total net area this institution.

Campus Level - Part II: Listing and Matrix Summaries

Part II contains various matrices based on the campus-by-campus data listed in Part I. The first matrix - Data Breakdown by Organizational Unit and Subject Field Code (detailed) versus Room Type - is given for every building on campus. It is detailed for Organizational Unit and Subject Field Code (codes 1110, 1520, etc.) and general for Room Types (100, 200, etc.). Every cell - the intersection of every row going across and every column going up and down - contains the number of rooms that satisfy the requirements for that cell, NASF for those rooms, the ratio of that NASF to the building's total NASF, the number of stations that satisfy the cell's requirements, the ratio of NASF to stations , and the standard deviation for that ratio. The last column contains combined figures for all Room Types of a particular Organizational Unit-Subject Field Code, while the last row shows combined figures for all Organizational Unit-Subject Field Codes for a particular Room Type. The interesection of this last row and column shows total number of rooms, NASF, etc. for the building.

A listing of Non-assignable Area by Room Type follows the matrix, and this combination of matrix and listing continues for every building on campus.

The second matrix is the same as the first except that the figures are carried to the campus level and the Non-assignable Area listing is omitted. The third matrix also follows the format of the first except that it details Room Type (110, 199, etc.) and leaves general the Organiza-

tional Units (1000, 2000, etc.).

The fourth matrix classifies Campus-wide General Room Types against General Organizational Units. Each cell contains only the number of rooms and the NASF. The matrix is followed by the Non-assignable Area Listing. These data satisfy the requirements of the 1969 HEGIS form 2300-7, Part B.

The fifth matrix - Data Breakdown by Type of School versus Degree of Graduate Program - first lists all existing school types (engineering, dental, etc.) in rows and then degrees of graduate program in columns. Each cell contains the number of buildings that satisfy matrix requirements and their combined NASF, while the last column shows the total of all degrees of graduate program for each type of school. The last row contains totals of all types of schools for each degree of graduate program, and the intersection of this row and column shows combined totals on campus. Following this matrix is a Listing of Area Devoted to Graduate Use and Percentage of Campus Total Assignable Area by type of school, graduate area, and percent of total campus area. Campus area devoted to graduate use is approximated by multiplying total areas of the columns for each row by the mean of the domain (1-9% = 5%, 10 - 24% = 17%, etc.) to obtain a weighted figure.

Five additional, detailed listings complete the Campus Level - Part II printout. The first is a building-by-building listing that relates NASF to Gross Area, Gross Area to Campus Total Gross Area, and Gross Research Area to Campus Total Gross Area. This section is followed by a detailed campus-wide listing of every room type (including Non-assignable Area) and its corresponding total NASF.

The third listing shows campus-wide totals of Gross Area, NASF, and the ratio between them; relates construction types to number of buildings, Gross Area, and decade of construction; and gives data about scheduled demolition including dates, number of buildings, and gross areas affected. The fourth listing gives financial data that include total costs of building and equipment, estimated value of buildings, sources of funds, number of sources, amounts provided by each source for every building, ownership codes, and the number of buildings, gross area, and value corresponding to each code.

The fifth and final listing of the Campus Level - Part II printout shows total institutional enrollment and NASF per student, based on total academic and auxiliary space.

State Level - Part I: Listing Summaries

The first page of this printout lists each type of institution according to federal codes for highest level of degree offered and type of program available. Each type of institution in this column is followed by a row of figures indicating its total Gross Area, total owned Gross Area, total Gross Area by type of ownership, and total Gross Area shared with other institutions of various kinds. At the bottom of the page these figures are summarized for all institutions of higher education in the state of Massachusetts. The final row on this page shows total Gross Areas constructed during each of the past five decades and before 1919.

Pages two and three list NASF for every Room Type. NASF progressively is broken down by broad categories of use, general Room Type, and detailed Room Type. Non-assignable and Unassigned Areas appear at the end of this section.

The next four pages list NASF by Organizational Unit-Subject Field Code. Again, NASF is broken down by stages - first by Organizational Unit, then by broad Subject Field category, and finally by specific Subject Field Code. Here, also, Non-assignable and Unassigned Areas appear at the end. A listing of NASF for each detailed Room Type appears next and is followed by figures showing State-wide Gross Area, State-wide NASF, and their ratio.

The State-wide Financial Data on the following page include totals for building costs, equipment costs, and estimated value of buildings. For buildings first occupied after June 30, 1958, they show sources of funds as well as number of buildings funded and total amount supplied by

each source. For each type of ownership, the State-wide Ownership Listing displays number of buildings owned, their total value, and their Gross Area. Finally, State Enrollment Figures provide the total fall of 1968 enrollment according to the Board of Higher Education of Massachusetts, the ratio of NASF to enrollment, and the standard deviation for that ratio.

State Level - Part II: Matrix Summaries

The first matrix breaks down institutional categories by the highest level of training offered versus the type of program provided. Each cell shows the number of schools that satisfy the cell's requirements, their combined NASF, and a weighted area figure (cell's % of state NASF/cell's % of number of institutions in the state). The fourth entry in each cell is a weighted enrollment figure (cell's % of state enrollment/cell's % of number of institutions in the state), and the fifth entry is a weighted NASF per student ratio carried forward from the campus to the state level (cell's % of state NASF/cell's % of state enrollment). The sixth and last figure represents NASF per student. Total Gross Areas for each category (I through V) appear in the last column and totals for each category (A through K) in the last row.

The second matrix - State-wide Data Breakdown by Organizational Unit-Subject Field Code (detailed) versus Room Type - uses general Room Type codes like 100, 200, etc. Each cell shows the number of rooms meeting cell requirements, their NASF, their NASF as a percentage of state NASF, their number of stations, their NASF per station, and the standard deviation for that ratio. The last column contains total NASF for each Organizational Unit-Subject Field Code listed, and the last row displays total NASF for each general Room Type. The intersection of this row and column shows total NASF for all Room Types and Organizational Unit-Subject Field Codes.

The third matrix follows the format of the second one, but it

shows Room Type (detailed) versus Organizational Unit-Subject Field Code using general Organizational Unit codes like 1000, 2000, etc. The types of information shown are identical with those of matrix two, and at the intersection of the last row (total NASF for Organizational Units) and the last column (total NASF for Room Types), the figures themselves are identical.

The fourth matrix, which simplifies the second and third ones, depicts Room Types versus Organizational Units using the general forms of both categories. The cells contain only two figures: one for the number of rooms meeting cell requirements and one for the combined NASF of this number. This matrix easily can be transposed onto the HEGIS form 2300-7. It is followed by a state-wide listing of Non-assignable Area by Room Type.

Both the fifth section - State-wide Data Breakdown by Type of School versus Degree of Graduate Program - and the sixth one - State-wide Listing of Area Devoted to Graduate Use and Percentage of State Total Assignable Area - carry to the state level the format of the parallel campus level matrix and listing (see pp.).

Except for the last one, all of the following matrices relate to various aspects of construction. In the sixth matrix - State-wide Data Breakdown by Construction Decade versus Type of Construction - each cell contains the number of buildings that meet cell requirements, their Gross Area, the ratio of their NASF to that area, the standard deviation of that ratio, and the percentage of Gross Area renovated. The last columns shows totals of all construction types for each decade. The last row

contains totals of all decades for each construction type, and the cell at which this row and column intersect displays total numbers of buildings for all types of construction and all construction decades, their total Gross Area, the ratio of their total NASF to that area, the standard deviation of that ratio, and the percentage of Gross Area that has undergone renovation. Matrix seven differs from this one only in that types of construction in the columns are replaced by condition codes; and matrix eight departs from the seventh one only by changing construction decades to renovation decades and necessarily eliminating the cell entry for percentage of Gross Area renovated.

The succeeding series of matrices shows type of construction versus condition for each of the past six decades, beginning with 1908-1917. Each cell in this series follows the format of the first construction matrix. The next matrix summarizes the preceding series, showing type of construction versus condition for all decades.

The last matrix - Enrollment versus Type of Institution - shows four levels of enrollment against types of institutions categorized both by the federal code for the highest level of degree offered and by their public or private status. Each cell shows the number of students, the NASF per student, and the standard deviation for that ratio. The last column shows totals of all categories at each enrollment level, and the last row provides totals of all enrollment levels for each category of institution. The figures in the cell at their intersection are for the whole state, irrespective of institutional category or level of enrollment.

State Level - Part III: Correlation Studies

Correlations were developed for four groups of studies. The first and largest of these concerned construction and renovation; it used a series of correlations in attempting to show the patterns of construction, renovation, and demolition of buildings according to their respective mean years.

The first correlation - Date of Construction versus Year To Be Demolished - typifies many others in the study. This correlation shows average year of construction against average year of demolition for all buildings scheduled to be demolished. It gives the number of points (buildings) used, the x-mean (mean year of construction), and the y-mean (year of demolition), followed by the x standard deviation and the y standard deviation. Following this basic information are three more figures - the correlation coefficient, the standard error of estimate, and the regression coefficient. These allow computation of the accuracy of the basic information. All six sets of information are supplied for all of the following correlations.

Correlations of Date of Construction versus Year To Be Demolished were performed for both renovated and unrenovated buildings; each attempts to show the mean year of construction against the mean year of scheduled demolition for each type of structure. Together they show the life span of renovated versus that of unrenovated buildings.

For renovated buildings, a fourth correlation shows mean year of construction versus mean year of renovation, and a fifth shows

mean year of scheduled demolition versus mean year of renovation.

A Listing of Renovated and Unrenovated Buildings shows for buildings in those two categories the percentage of buildings constructed in various ways (wood, masonry, concrete, etc.), the percentage in various states of repair (ranging from "satisfactory" to "should be razed"), and the percentage scheduled for demolition. A matrix - Year To Be Demolished versus Renovated and Unrenovated Buildings - plots the data contained in the preceding correlations. It shows categories by Renovated and Unrenovated Buildings against the years in which they are scheduled for demolition, from 1969 through 1983. The information in each cell shows the number of buildings that conform to the cells' requirements, their Gross Area, average year of construction, and standard deviation.

Gross Area Studies rely on four correlations that attempt to show trends in the amount of academic and auxiliary areas renovated in the past fifteen years and scheduled for demolition in the next fifteen years. The first correlation shows the x mean as the average year of renovation and the y mean as the average academic area renovated per year in the past fifteen years. The second correlation shows the same information for auxiliary area. Correlations three and four show the average area of demolition per year scheduled for academic area over the next fifteen years and the same information for auxiliary area.

The series of correlations that support Financial Studies first attempts to show how Gross Area relates to cost per square foot and then tries to depict the changing costs of construction for academic

and auxiliary area over the years. The first correlation plots the average Gross Area per building against the cost per square foot for construction of academic area, and the second does the same for auxiliary area. Correlations three and four show, for buildings constructed between 1930 and 1939, the average year of construction versus the average cost per square foot of academic and auxiliary area respectively. These correlations are repeated for the succeeding decades.

Three correlations are used for Gross Area per Student Studies. They show mean Gross Area of academic space per student during the past twenty-two years, mean Gross Area in the state during the past twenty-two years, and mean enrollment during the same period.

CHAPTER IV ANALYSES OF STATE-LEVEL OUTPUTS

The goals of the statewide analyses are to set the general dimensions of the demand for academic facilities over the next ten years and to develop a resource model that can be used to improve forecasting. To help attain these goals, outputs from the FIPS data base were generated in three sets of programs: the Listing program, the Matrix program, and the Plot program.[3/] Analyses in this chapter are divided according to the source program of the outputs. Data at the State Summary level are generalized. Since these data subsume the Campus Summary outputs, the state-level analyses also illustrate the types of conclusions available to participating institutions.

In general terms, analysis shows a statewide NASF (Net Assignable Square Feet) of academic space per student of 120.75, and an NASF of auxiliary space per student of 115.61. These and similar figures are based on institutional enrollment data, which cover full-time graduate and undergraduate students. These data are distinct from state enrollment, which is a head-count covering full-time and part-time graduate and undergraduate students. Codes for academic space include all numbers except 080 and the 600's, 800's and 900's, which designate auxiliary space.

3/ See Appendix A

Analysis of State Summary - Part I

State Summary of Area by Type of Institution and Ownership Codes: Gross area in the state totals 65,808,280 square feet, of which the institutions themselves own 59.7 million square feet (90%). 3.2 million square feet are vested in holding companies. Institutions that confer the Ph. D. account for 32 million square feet, or 50% of the gross area in the state. Schools that offer M. A. 's and/or a second professional degree hold 15.2 million square feet. Schools conferring Ph. D. 's and those conferring M. A. 's together account for 83% of the area in the state.

Year Constructed: Almost one third of the 65.8 million gross square feet in the state were built in the last decade (1959-1968). 19.2 million square feet are known to be more than 50 years old; much of the 12 million square feet classified "unknown" probably is just as old. 5.8 million square feet were constructed during 1919-1928, the post-World War I period. This amount decreased to 3.4 million during the Depression and continued to diminish during World War II. During 1949-1958, the post-World War II period, construction doubled to 6.5 million; then, in 1959-1968, it tripled in response to the need for additional facilities to accomodate the college age children of the post-World War baby boom.

Type Facilities Based on Room Classification:

Facilities	Millions of NASF
Assignable Area	42.0
Total Academic Area	21.2
100 Classrooms	3.1
200 Laboratories	5.5
Teaching 3.3	
Non-Class 2.2	
300 Offices	5.3
400 Library and Special Study	2.7
500 Special	2.0
700 Support	2.6
Total Auxiliary Area	20.8
600 General	4.2
900 Residential	15.4
Other (including 800)	1.2
Non-Assignable Area	23.4
Total Gross Area	65.4

This listing shows that for every two square feet of assignable space, a third square foot of non-assignable space must be constructed. * 23.4 million square feet (36%) of the gross area in the state is listed as non-assignable, mechanical, custodial, circulations, or construction area. Of the academic areas, classrooms account for 3.1 million square feet; yet offices require 5.3 million square feet. Laboratories (5.5 million square feet) and classrooms, the basic areas used in teaching, totalled 8.6 million square feet , or 13% of the state gross area; but construction alone ac-

* This efficiency ratio (net assignable/gross square feet) of 64% cannot be used as a planning standard, for it does not apply equally to all types of facilities. Most academic buildings, including laboratory, classroom, seminar, and office facilities, will require efficiency ratios ranging from 56% to 62%; but major support, auxiliary, and single-purpose buildings, including library, athletic, residential, and service facilities, may achieve efficiency ratios ranging from 62% to 70%.

counted for the same percentage. Library and study space occupy 2.7 million square feet; special-use facilities (physical education, audio-visual, etc.) account for 2.0 million square feet, and support facilities use 2.6 million square feet. These areas, combined with classrooms, laboratories, and offices, accounted for 21.2 million square feet, or 32% of gross area in the state. Auxiliary areas (20.8 million square feet) also occupied 32% of gross area in the state. Residential facilities were the largest sector (15.4 million square feet); general and other uses accounted for the other 5.4 million square feet. Thus the teaching and study areas - classrooms, laboratories, libraries, and gymnasiums - account for only 20% of state gross area (13.3 million square feet.)

State Summary of Type of Activity by Organizational Units and Subject Field Codes:

Activity	Millions of NASF
Academic Activities	17.1
1000 Departments of Instruction	12.8
2000 Organized Activities Units	0.5
3000 Organized Research Units	1.0
4000 Public Service	0.2
5000	2.6
Auxiliary Activities	23.5
6000 General Administration and Institutional Services	3.2
7000 Auxiliary Services	20.1
8000 Non-Institutional Agencies	0.2
Unassigned	1.2
Non-Assignable	23.4
Gross Area	65.2 [4]/

This listing shows that most of the area in the state is not devoted to

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[4]/ with .2 error as a result of rounding off decimals.

academic activities, for non-assignable area accounts for 23.4 million square feet, and unassigned area for 1.2 million square feet. Auxiliary activities include General Administrative and Institutional Services (Code 6000,, 3.2 million square feet), Auxiliary Services (Code 7000, 20.1 million square feet), and Non-Institutional Agencies (Code 8000, 0.2 million square feet). Their total is 23.5 million square feet, which leaves approximately 17.1 million square feet for academic activities. Departments of Instruction is the largest organizational unit (12.8 million square feet); Libraries account for 2.6 million square feet, Organized Activity units for 0.5 million square feet, Research areas for 1.0 million square feet, and Public Service units for 0.2 million square feet.

Among the Departments of Instruction and Research, which use 12.8 million, or 19% of gross area in the state, the M.C.P.E. Sciences dominate, accounting for 3.5 million square feet, or 25% of the total area for instruction and research. Life Sciences are next (2 million square feet, or 16% of the total area), followed by Behavioral Sciences (0.6 million or 5%). Thus, 6.1 million square feet, or 47% of total gross area for instruction and research, is devoted to the Sciences. The Humanities occupy only 1.38 million square feet, or 10% of the total. The rest is devoted to Professions, Technical-Vocational, and Physical Education and Military Sciences, which occupied more area than Humanities - 17.6 million square feet.

Of the 6.1 million square feet occupied by the Sciences, laboratories take up the most space - 3.8 million square feet, or more than half the total area for Sciences. Classrooms occupy 0.4 million square feet, and libraries account for 0.1 million. For the Humanities, laboratories (mainly art studios) are the largest sector. They use 0.4 million square feet, or 29% of the 1.4 million square feet total for Humanities. Classrooms occupy 0.3 million square feet, and libraries account for .04 million square feet. The Sciences have a higher ratio of laboratory area to gross area of all room types (62%) than do the Humanities (32%). The ratio of classroom area to gross area for the ciences (7%) is lower than that for the Humanities (21%). Most Humanities courses, however, and many Science courses use unclassified General Classrooms, which occupy 1.8 million square feet, and General Libraries, which account for approximately 2.7 million square feet. Laboratories are an inseparable part of classroom science teaching and require more NASF per student than do classrooms. Humanities courses (usually art) require few laboratories, which explains the dominance of area devoted to Sciences. The Humanities do not necessarily occupy too little space; they simply require less area per student.

Organized Activity Units account for 544 thousand square feet, less than 5% of the total area in the state. Here again, the Sciences dominate, for the area used for scientific demonstrations totals 456 thousand square feet, 83% of the area for Organized Activity Units.

Outside the Sciences, only Education used a significant area - 29,780 square feet for demonstration purposes.

Organized Research Units, which are research institutes, laboratories, museums, etc., that are organizationally separate and physically identifiable, occupy one million square feet. Almost half of that (415,531 square feet) is listed as general research units. This fact probably reflects the currect popularity of multi-disciplinary studies in instructional areas and the tendency of research institutes to solve milti-disciplinary problems. The Sciences still dominate, and the physical and engineering sciences compete with General Research Institutes: they occupy 142 and 268 thousand square feet, respectively. The Sciences together overtake the General Research Institutes by 95 thousand square feet and leave the Humanities and Professions only 52 thousand square feet. All other units account for 54 thousand square feet.

Listing of Area by Room Type: See above, Type of Facilities Based on Room Classification.

State Area Listings: State-wide Gross Area for 1968 was 65,809,265 square feet; of that, 41,999,014 square feet constituted the state total Assignable Area. Thus, the ratio of Gross Area to Assignable Area is 0.64.

Financial Data: The total cost of buildings in the state was 1.1 billion dollars, a figure that includes cost of equipment and all other investments after initial construction.* This figure is not entirely reliable, for it excludes costs such as architect's fees and land costs. The total cost for equipment was 115.6 million dollars. Thus equipment costs generally are 10% of building costs. This figure varies, for classrooms require little equipment, while scientific facilities need more than other types. Moreover, it is understated because many equipment costs could not be separated from building costs. The total present estimated insurable value of these buildings is 1.9 billion dollars.†

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* Note that this sum was spent over more than sixty years and therefore bears little relationship to the value of the buildings in today's dollars, which have been affected both by inflation and by rising construction costs.

† Because of inflation, rising construction costs, and great differences in types of insurance, estimated insurable value is not equivalent to replacement value.

State-Wide Sources of Funds:

Sources of Funds	Number of Buildings	Amount of Funds (in thousands)
Total for Private Sources	1,299	$684,697
18 Gifts and Grants	397	201,135
19 Current Funds	351	330,419
20 Income or Loans from Endowment Fund	156	34,418
21 Income or Loans from Other College Funds	154	15,924
22 Private or Commercial Loans	209	99,796
13, 16, 17 Other Private Sources	33	3,059
Total for State Government Sources	251	177,007
1 Appropriations	188	84,794
11 Building Authorities	56	65,288
8, 10 Other Taxes and Bonds	7	26,925
Total for Federal Government Sources	201	162,925
3 Grants - Title I HEFA (Higher Education Facilities Act)	32	25,302
4 Grants - Title II HEFA	4	2,291
5, 6, 7 Public Health Service and Others	55	28,179
14 Loans - Title III HEFA	5	2,897
15 Loans - HHFA (House and Home Finance Agency)	105	104,256
Total for Local Government Sources (2, 9, 12)	7	396
Total for Other Sources	34	2,233
Total of All Sources	1,793	$1,027,317

The types of funds used to construct or acquire buildings were listed only for buildings initially occupied after June 30, 1958. Most funds are generated by the institutions for themselves, in the form of grants, gifts, and current institution funds, which totalled 632 million dollars. Gifts and grants (Code 18) funded 397 buildings, and current funds (Code 19) accounted for 351. The next largest group of sources are income and loans from endowment (Code 20) or other college funds (Code 21) and loans from private or commercial sources (Code 22). These sources financed 519 buildings and totalled 140 million dollars.[5/] 104 dormitories were built through the House and Home Finance Agency (Code 15),which supplied 104 million dollars. Other private sources (Codes 13, 16, and 17) provided approximately 3 million dollars for 33 buildings.

State government appropriations (Code 1) provided more funds than either the federal or the local government - 85 million dollars, to build 188 buildings. State building authorities (Code 11) issued bonds to finance 56 dormitories at a cost of 65 million dollars, which sutdent fees will repay. General obligation bonds (Code 10) provided 5 academic buildings; 1 was built through direct tax levy (Code 8).

The federal government participated in funding few buildings, all of them through the Higher Education Facilities Act or the House and Home Finance Agency (see above). Under Title I of HEFA (Code 3), it

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5/ Auxiliary space tends to be funded by loans that are amortized by student fees.

contributed to 32 academic buildings for undergraduate use. Title II (Code 4) contributed to construction of 5 buildings. Together, HEFA of 1963 provided only 30.5 million dollars for academic construction in Massachusetts. Various national agencies (Codes 5,6, and 7) like the National Science Foundation and the National Aeronautics and Space Administration contributed to construction of 55 buildings at a cost of 28 million dollars. Local governments (Codes 2,9, and 12) provided 396 thousand dollars for buildings.

Thus the institutions themselves had to rely on donors or state sources to obtain revenue for constructing most of their buildings. 1409 buildings were financed institutionally (including Title III and HHFA loans), and 251 through state sources (including State Building Authorities). 91 buildings were financed through federal grants.

Statewide Ownership Listing: Of the 2415 listed buildings, 2287 (95%) were owned by the institution. These buildings are valued at 1.78 billion dollars (out of a total of 1.87 billion dollars for all ownership listings) and contain 97% of the State Gross Area. Of the remaining buildings, 63 are now vested in a holding company, 48 are leased (most of these for state community colleges), and 16 are provided at minimal cost.

Enrollment Data: The enrollment head-count for the Fall of 1968 was

261,316 studen ts (graduate-undergraduate, full-time - part-time), and the ratio of state NASF to that figure is 160.721 (square feet per student). The great variations in this figure from institution to institution will be discussed in the next matrix.

Analysis of State Summary - Part II

State-Wide Breakdown by Type of Institution: This matrix categorizes institutions by the highest level of degree offered (coded I-V) and by the type of program available (coded A through K). Of the ninety participating institutions, the largest classification (twenty-two schools) comprised institutions offering two but less than four years of education beyond the twelfth grade with liberal arts, general, and terminal-occupational programs that lead to a bachelor's degree. The size of this classification results from the twelve state community colleges that it includes. The next largest classification (eleven schools) consisted of institutions offering liberal arts, general, and teacher preparatory programs leading to a Master's and/or a second professional degree. Of these, eight were state colleges. In looking at the distribution of institutions according to the highest level of degree offered, we see that the largest number, twenty-nine, offered two but less than four years of study. If an institution expands its curriculum from this level, it tends to offer Master's and second professional degrees, as twenty-six schools did. Nineteen institutions offer a Master's and the first professional degree, thirteen offer Doctorates in Philosophy, and three are professional schools.

While the junior and community colleges compose the largest category of schools, their areas are not commensurate. They account for 33% of all

institutions of higher education in the state, but their total NASF is 3.2 million, only 8% of the state area to their number as a percentage of the total number of schools (.08/.33, shown as the second figure in each cell), is only .24; in other words, they have less than one-fourth the area of the average institution in the state (where 1.00 represents the weighted average). Classification I C, which contains only the community colleges, fares even worse, for its weighted ratio is only .19, .05 below the classification's average. On the other hand, Category IV, which has only 13 schools, contains 24.9 million NASF, 60% of the state total NASF. Of this category, the seven institutions offering Doctorates of Philosophy with 3 or more professional schools (IV K) have 20.4 million NASF, 6.31 times the area of the average institution. This is understandable, since these institutions also have much larger enrollments. The fourth figure in each cell shows the ratio of the cell's enrollment as a percentage of state enrollment to the number of schools in the cell as a percentage of the total number of schools. Thus, although IV K has 6.31 times the area of the average school, it also has 5.95 times the number of students of the average school. These figures produce a weighted area to enrollment ratio of 6.31 to 5.95, or 1.06, which is the fifth figure in each cell. Thus, the weighted area per student ratio for IV K schools in only .06 higher than the average. Although schools of category I have only 24% of the area of the average school, they also have only 41%of the number of students of the average school.

Thus the weighted result is that each community and junior college

student has only 60% as much space as the average student. The university student has almost twice as much NASF as the junior or community college student. Category III has average shares of both area and enrollment so that extremes of distribution are accounted for by Categories I and II at the low end and Categories IV and V at the high end.

The state NASF per student is 236 square feet, but this figure varies from 57 NASF per student in classification III K to 564 NASF per student in classification V G. These extremes account for only four schools. The classifications that contain the community colleges (I C) and the state colleges (III E) have 100 and 184 NASF per student, respectively, which shows that most state institutions tend to fall below the state average. These figures are inflated for the state institutions because of the higher NASF/student averages of the private institutions in the same cell. Private schools fluctuate above and below the average with a tendency to have increasingly larger NASF per student from I to V.

Institutional Categories I - V versus Total NASF, Auxiliary, Academic, and Library Area: The preceding matrix was unable to define the large differences in NASF/student. This matrix, constructed after the initial state matrix program, attempts to give more perspective on the actual uses of the various NASF/student figures. It is divided into Public and Private institutions (Categories I through V) according to academic,

auxiliary, and library area available to students across the state. Academic area is the most important in determining how well higher educational facilities meet demand.

Twenty-one public institutions with 8.3 million NASF participated in the study, as did private institutions with 33.7 million NASF. For every student at public institutions there were two at private institutions; public institutions averaged 145.00 NASF/student, and private institutions, 279.65 NASF/student. Thus the student at a private institution generally has almost twice as much assignable area as the student at a public institution. This inequity also holds for academic and auxiliary area - 75.44 academic NASF/student and 69.56 auxiliary NASF/student for public institutions, but 141.24 academic NASF/student and 138.41 auxiliary NASF/student for private institutions. The inequity in library area is even greater - 5.83 NASF/student in public institutions versus 19.32 NASF/student in private institutions, a ratio of 1:3.3.

The NASF/student for public institutions ranges from 76.34 for Category I community colleges, to 230.53 for Category V professional schools. Category V is an exception rather than the rule, for it includes only three schools, one of which had a very large area but very few students, which skewed the whole category to the upper range. For the same reason, this category has the highest academic NASF/student - 433.67 - as well as the highest library NASF/student - 68.12, which is greater than the <u>total</u> NASF of two public institution categories. Because category V

is such an exception, and because there are no public institutions in the category, we have excluded it from comparisons of public and private institutions and from 89.20 to 154.33 (excluding Category V) for private institutions. Auxiliary NASF/student ranges from 16.74 to 115.07 for public institutions and from 118.01 to 212.36 for private institutions.

For every NASF/student in a public institution in categories I through V, private institutions in categories I, II, and III have, respectively, 2.9, 2.6; and 2.8 NASF/student. Only category IV of private institutions is more equitable, with ratio of 1:1.2. The ratios of academic NASF/ student in public institutions to academic NASF/student in private institutions also are more equal - 1:1.9, 1:1.2, 1:2.4, and 1:1.3 for categories I, II, III, and IV. The 1:1.2 ratio of category II represents 71.14 academic NASF/student to 88.34 academic NAST/student. The almost equal ratio of category IV, 1:1.3, represents the highest academic NASF/ student for public and private institutions - 115.46 and 154.33. This is because graduate students at universities (category IV) probably require more space than undergraduates, especially when one student occupies a whole laboratory or office. If we account for the many part-time students that category IV facilities accomodate, the real NASF/student figures probably are higher. Categories I and III show greater variance than II and IV - Category I, with a ratio of 1:1.9, is 46.92 academic NASF/ student to 89.20 academic NASF/student for public and private institutions; Category

III, with a ratio of 1:2.4, is 56.25 academic NASF/student to 137.89 academic NASF/student. Category I (public) contains the community colleges, and category III (public) contains the state colleges. From the great discrepancy between academic NASF/student in public and private institutions of these categories, we must conclude either that the private institutions have more academic area per student than they absolutely need, or that the public institutions need more facilities. As community and state colleges have less academic area per student than other public institutions, the second conclusion seems more probable; but we must remember that enrollment figures are not strictly comparable because of differing methods for determining enrollment, and curricula between and within categories differ in their space requirements.

Though the community colleges have fewer NASF/student (46.92) than the state colleges (56.25), their less advanced degree offerings do not require as much laboratory space as the state colleges. Thus their lack of space is not as crucial as it is for the state colleges, which require more laboratories, and therefore much more area.

The variance between public and private academic area per student is not as great as that for total NASF/student, which is affected by the great variance between public and private auxiliary area. The greatest variance is in category II, with a ratio of 1:8.4; it is caused by the fact that public institutions in this category are mostly non-residential, while the private institutions house all their students. This fact also determines the ratio of total NASF/student in community colleges to total NASF/student in junior colleges - 1:4.4. This ratio decreases to 1:3.2 for category III because the state colleges house some of their students; but it becomes almost equal in category IV which has the

highest auxiliary NASF/student (115.07) for public institutions and the lowest (118.07) for private institutions, because universities uniformly do not or cannot house all their students.

In library space the trend continues: private institutions have 3.3 times as much library area/student as public institutions.* The ratios of public to private library area per student range from 1:4.4 for category III to 1:1.8 for category II. Private institutions in category III have the most library area per student (21.20) while state colleges in the same category rank next to the lowest for public institutions (4.87), which explains the large ratio for this category. Category IV has a lower library NASF/student than category III because universities have much larger enrollments than category III colleges, and each library has the minimum area necessary to accomodate its students. Thus, the size of a reading room does not necessarily increase with increased enrollment; rather, it remains the same but subject to greater use.

Category I has the lowest library NASF/student for both public and private institutions - 4.10 and 9.78, respectively. Yet the public institutions have the most acute need for library facilities in light of the fact that even the private institution low of 9.78 library NASF/student in junior colleges is higher than the figure for any public institution category.

In general, the wide gap between NASF/student figures for public and private institutions is mitigated by extracting figures for academic and auxiliary NASF/student. The academic area figures alone correct the

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* Note, however, that there are different kinds of library space - large institutions have listed specialized, research, and deposit libraries that are used by fewer people than use ordinary college libraries directly related to course work.

misconception that the very high NASF/student figures for some institutions are a measure of how well those institutions meet demands for the academic facilities necessary to quality performance; for analysis shows that such institutions allocate about two-thirds of their total NASF/student to auxiliary purposes

State - wide breakdown by Organization and Subject Field Code versus Room Type Code: This matrix provides a comprehensive breakdown for each Organizational Unit and Subject Field Code by Room Type. Followed by the matrix called "Statewide Data Breakdown by Room Type (Detailed) versus Organizational and Subject Field Code," this matrix provides essentially the same facts as those discussed in the previous, Part I listing programs of Room Types as well as Organizational Units and Subject Field Codes. The matrix is too detailed to permit deciphering trends. It basically is used for looking at specific information.

Room Type versus Organizational Unit for HEGIS Form: This is a further extraction of the last two matrices.

State-Wide Breakdown by Type of School versus Degree of Graduate Program: This matrix attempts to show the state-wide level of graduate facilities by type of schools. Conclusions, however, are not very reliable, because it is difficult to estimate a building's degree of use for graduate programs. The

overview is also distorted by inconsistent and indiscriminate use of Code 20, which involves 31 of the 36 million gross square feet listed. While we can dismiss the 22.5 million square feet of classification 20-1 (other-no graduate use) as representing all undergraduate facilities, we cannot avoid seeing that 9 million square feet, of varying degrees of graduate use, are listed as code 20, while only 5 million are listed in all other categories of graduate use and school type. In code 20 and degree of graduate program 2 through 6, institutions included anything from dormitories to office buildings to professional schools, such as business school, not listed in codes 1 through 19, to buildings whose use is distributed equally between any of the code 1 through 19 uses. Thus, some dormitories used to house graduate students are coded 20 and degree of graduate program 6; the same is true for buildings equally distributed between biology and chemistry laboratories for graduate students and for a business school building. All three appear in the same cell, but only the last ideally should be listed. We are unable to draw many conclusions because of inconsistent coding. Setting code 20 aside as undeciphirable, and concentrating on codes 1 through 19, we find that the sciences - engineering, biology, physical, computing, and mathematical - dominate with 2.4 million square feet, or almost 50% of the 5.1 million square feet in codes 1 through 19. This area, however, is grossly under-reported because two sizable private institutions either listed no degree of graduate program or failed to enter certain

buildings, which therefore were excluded from this matrix, The next largest gross area is devoted to education (834,833 square feet), followed by the medical-health professions - dental, medicine, nursing, and public health - with 779,796 square feet. Law schools have 346,607 square feet, and agriculture shows 334,680 square feet. Again, these data may not be completely reliable because of possible intermingling of graduate programs within one building.

State-Wide Listing of Area Devoted to Graduate Use and Percentage of State Total Assignable Area: This matrix uses the preceding information to show us the approximate area actually devoted to graduate use of a particular professional school where only a percentage of a building is used. The formula used to calculate the graduate use area is obtained by taking the mean percent of each degree range (degree 6, for example, is 75% to 100% with a mean of 88%) multiplied by the gross area of the buildings. Of the 2.4 million gross square feet listed in the previous matrix for the sciences, the actual area devoted to graduate use is only 820,220 square feet, or 34% of all buildings listed with some graduate use. But the absence from the matrix of data from the two large private institutions, where many buildings are totally devoted to graduate use, undermines the 34% figure. The medical - health professions have 591,526 square feet devoted to graduate use; approximately

75% of all the buildings listed for these professions are devoted to graduate use. This figure is reliable and expected since medical and dental schools are devoted totally to graduate students, and public health almost totally.

State-Wide Data Breakdown by Construction Decade versus Type of Construction: This matrix includes only buildings known to have been built between 1908 and 1968 and accounts for 46 million gross square feet of the 65.8 million gross square feet of all buildings constructed in the state. Of this total, 20.6 million (nearly half) were built in the last decade, 1958-1968. 7.5 million square feet were constructed during 1908-1917. Construction decreases from that decade until it bottoms at 2.6 million square feet during 1938-1947 and finally shifts upward to 6 million after the war. Starting in 1958, construction increased dramatically, reflecting both increased concern for higher education and the need to accomodate the increasingly large numbers of college age people born during the Post-World War II baby boom.

In studying the average size of buildings by construction decade, we note no significant trend except for a dramatic increase in the size of buildings constructed in the last decade (1958-1968) - an average of 37,400 square feet/building versus 25,000 square feet/building from 1908 to 1958. This increase in size resulted from an increasing use of concrete for building

0 | 2M 10% | 4M 20% | 6M 30% | 8M 40% | 10M 50% | 12M 60% | 14M 70% | 16M 80% | 18M 90% | 20M 100%

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918

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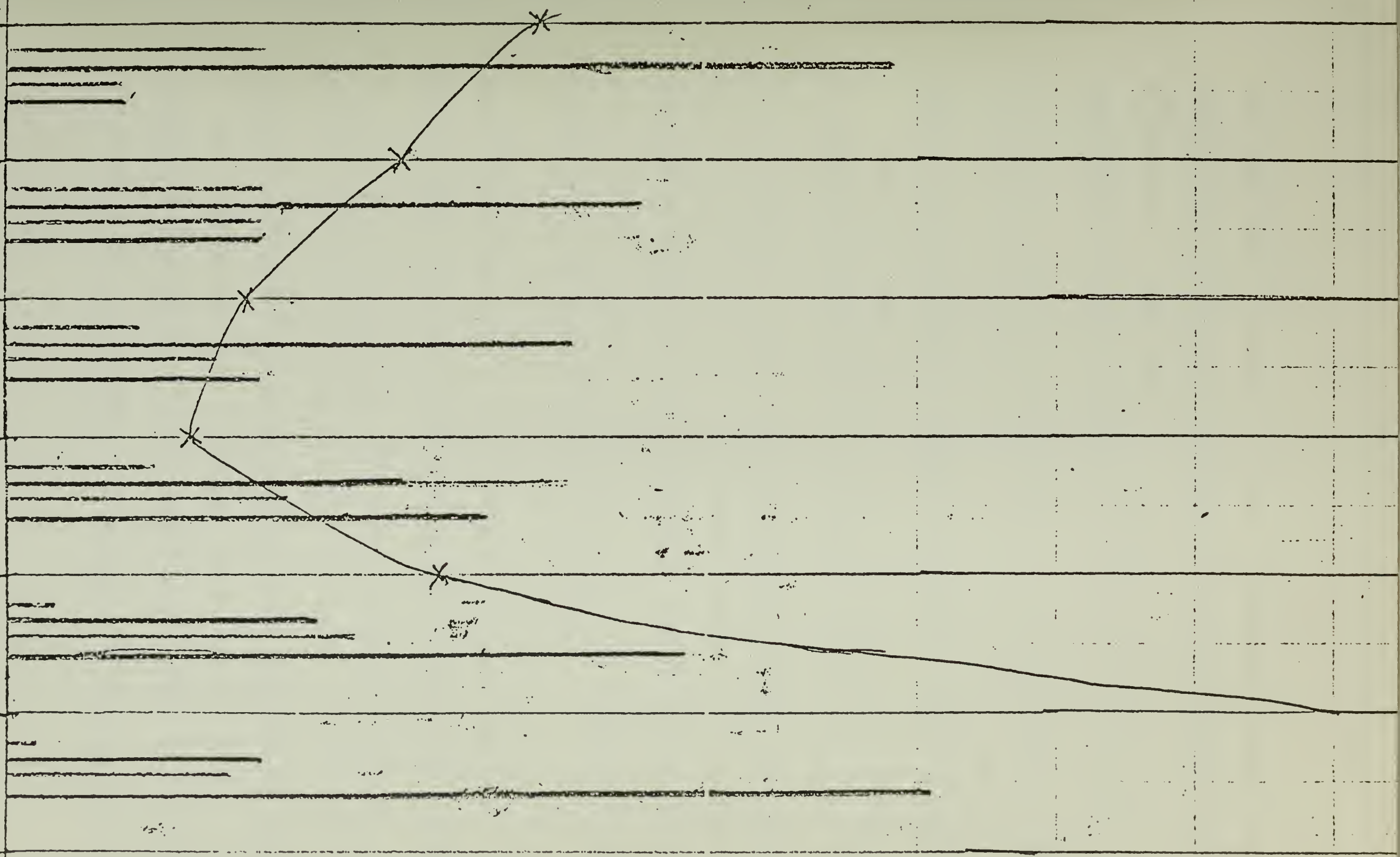
938

948

958



YEAR – TOTAL CONSTRUCTION GROSS AREA
WOOD AS % OF TOTAL AREA
MASONRY AS % OF TOTAL AREA
STEEL-SKELETON AS % OF TOTAL AREA
CONCRETE AS PERCENTAGE OF TOTAL AREA

FIGURE 1.

rather than wood or masonry. Wood-frame buildings (codes 1 and 2) average only 7,000 square feet/building and masonry (codes 2 and 3) average 29,000 square feet/building; but buildings of reinforced concrete and other steel-skeleton buildings (codes 6, 7, and 5) average over 50,000 square feet per building. During the decade 1908-1917, wood and masonry buildings accounted for almost 80% of total construction; by 1958, reinforced concrete and steel skeleton buildings accounted for 82% of all construction.

While NASF per building is higher for wood-frame buildings than for reinforced concrete (70% versus 60%),wood-frame structures vary more from the mean than concrete ones. During each decade, wood-frame structures continually had to be renovated twice as much as corresponding reinforced concrete structures. Generally, reinforced concrete structures repidly are replacing wood and masonry structures because they can be built large and can last longer without renovation.

State-Wide Breakdown by Construction Decade versus Condition: 1346 (86%) of all buildings listed with condition codes are in satisfactory condition. But, more than half of the buildings constructed during 1908-1917 that still are in good condition have undergone major renovation. The percentage of buildings in satisfactory condition that have been renovated decreases steadily for each successive decade, from 56% in 1908-1917 to only 5% in 1958-1967. Compared with buildings in good condition, fewer of the 155 buildings in need of major renovation (codes 2, 3, and 4) have undergone major renovation.

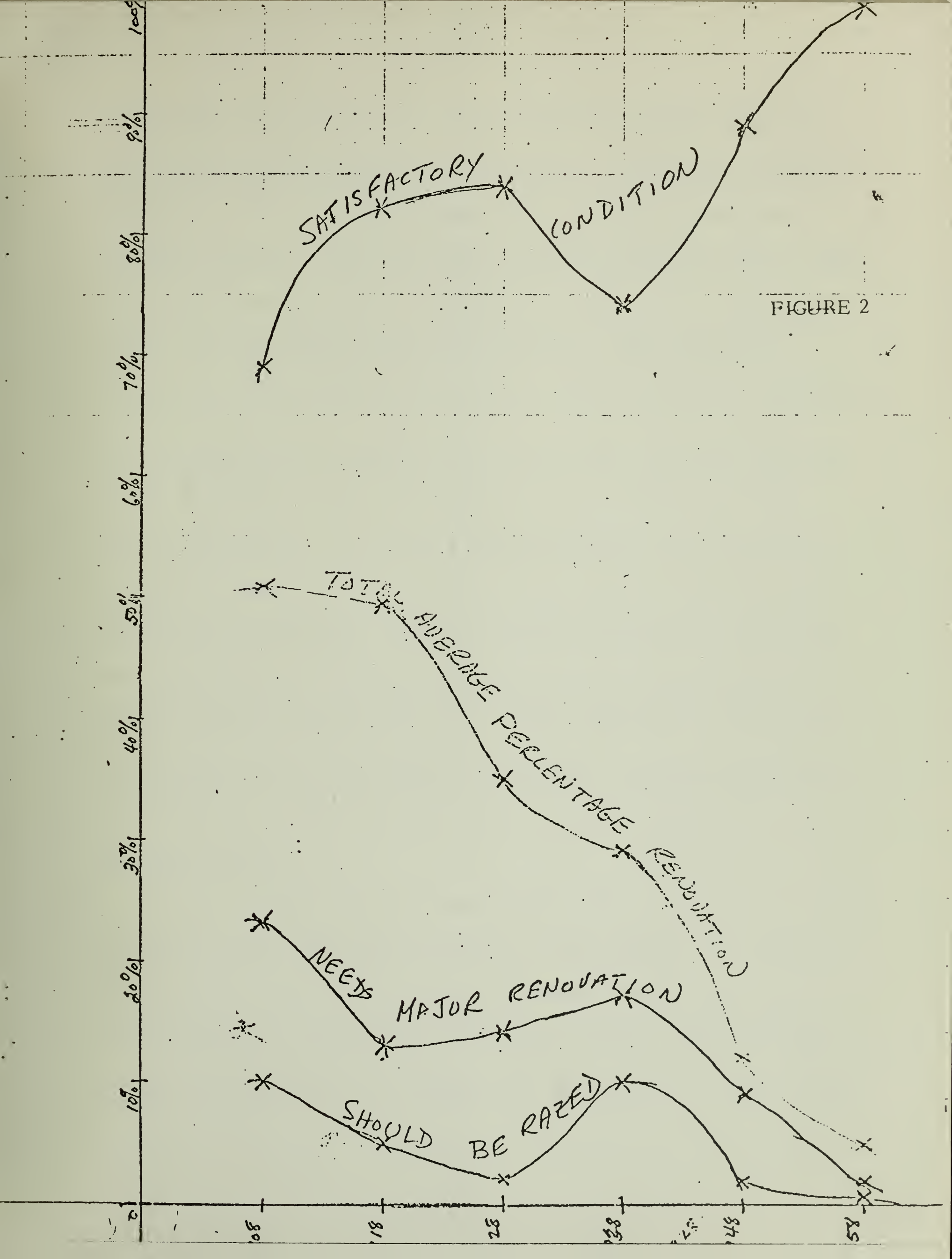

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0
SATISFACTORY
CONDITION
TOTAL AVERAGE PERCENTAGE RENOVATION
NEEDS MAJOR RENOVATION
SHOULD BE RAZED

FIGURE 2

Nearly 70% of all renovation occurred in the decade 1958-1967. 80% of all renovated buildings still are in good condition, including four buildings renovated in 1908-1917. Surprisingly, this matrix shows that eighteen buildings renovated in 1958-1967 also are listed as "should be razed", while fifty-four buildings renovated in that decade now need another major renovation. This distribution among "good condition", "need for another renovation", and "should be razed" seems to apply irrespective of the decade.

State-Wide Breakdown by Type of Construction versus Condition: This is a series of matrices, one for each decade beginning in 1908, 1918, 1928, 1938, 1948, and 1958. It provides a three-dimensional view of the effects of aging on condition, percent of buildings renovated by construction type, and decade of construction. 69% of the buildings constructed in 1908-1917 are in good condition. This percentage increases for two successive decades to 82% and 84% and decreased to 74% for 1938-1947. It increases again to 99% for those constructed in decade 1958. Inversely, the percentage of buildings needing major renovation or razing decreases with each successive decade.

In order to obtain a more precise view of the 69% of buildings constructed in decade 1908 that are in good condition, we must note that they represent all construction types. 81% of masonry buildings and 91% of buildings of steel-skeleton with masonry walls are in good condition. 58% of buildings of wood and 60% of concrete buildings are in good condition. Approximately

61% of masonry buildings and buildings of steel skeleton with masonty walls, however, are renovated buildings in good condition, while 53% of wooden buildings and only 11% of concrete buildings are renovated and in good condition. Clearly, more concrete buildings can remain in better condition with less need for renovation than other types, although steel-skeleton masonry is almost as durable. This generalization remains relatively true for each successive decade.

Of the buildings constructed in 1908-1917 in need of major renovation, the percentage already renovated varies greatly and at times seems contradictory: for example, while only one of the ten concrete buildings constructed 1908-1917 and in good condition has been renovated, 50% of the buildings in need of major renovation already have been renovated. Again, 85% of wood buildings constructed in 1908-1917 and in need of renovation already have been renovated, while only 51% of those in good condition have had renovation. This relation is reversed for masonry buildings, only 20% of which in the first category have been renovated against 59% in good condition that have been renovated. These figures probably are influenced by the dates of renovation, for which this matrix cannot provide. We conclude, however, that concrete and steel-skeleton masonry generally age better than either wood-frame or masonry buildings.
There is only one steel-skeleton masonry building and one concrete building listed as "should be razed" while 46 wood and 12 masonry buildings are so listed. The steel-skeleton masonry building that needs razing has

been renovated. The concrete building, which was constructed in 1918-1927 has not. 27% of the wood-frame buildings and 12% of the masonry buildings have been renovated.

These six matrices are followed by a matrix summary of all the decades.

Enrollment versus Type of Institution: The enrollment data for this matrix represent numbers of full-time graduate and undergraduate students registered at institutions as of Fall, 1968. The institution categories I through V are divided into public and private.

Of the twenty-nine public and sixty-one private institutions, those in the 0-2000 enrollment category predominate with twenty-two public and fifty-one private institutions. Eleven institutions have between 2,000 and 6,000 students. Four private institutions have between 6,000 and 15,000 students, and two private institutions have enrollments higher than 15,000.

As an earlier matrix showed, NASF/student figures for private institutions are generally more than twice those of comparable public institutions; and while these figures vary greatly for private institutions, they remain basically uniform for public ones.

The present matrix shows that as an institution offers a higher level of degree, its enrollment increases. All the category I two-year community colleges and junior colleges belong in the 0-2000 enrollment category, All

but oneof the category II colleges also are in the 0-2000 category; the exception is a public institution in the 2-6000 category. Six of the twenty-six institutions in category III that offer Masters degrees have 2,000-6,000 students, while three of the thirteen institutions in category IV that offer Doctorates of Philosophy fall into the 0-2,000 category. Four category IV institutions have between 2,000 and 6,000 students, four have between 6,000 and 15,000, and two have more than 15,000 students. All the category V professional institutions have fewer than 2,000 students.

Analysis of State Summary - Part III

Renovation and Demolition

Fifteen percent (384) of the buildings in the state have been renovated. Buildings scheduled for demolition have, on the average, lasted eighty years, and renovation does not appear to extend that span. Thirty-one of the eighty buildings scheduled for demolition have at one time undergone major renovation (greater than 50% of their area). When a building is renovated, the process follows construction by forty years, but this period can vary.

Renovated and non-renovated buildings differ significantly in both type of construction and condition. 76.1% of the renovated buildings are built of wood or wood-frame and masonry, and 22.3% of steel skeleton or concrete. Only 48.6% of the non-renovated buildings, though, are built of wood or wood-frame and masonry, and 45.5% of steel skeleton or concrete. On the average, renovated buildings are in slightly worse condition than non-renovated buildings. These facts suggest that: (a) wood and wood-frame and masonry structures are more amenable to renovation than other types, and/or (b) wood and wood-frame and masonry structures are less sturdy than other types and require renovation to remain useful. *

Over the past fifteen years, the gross area of buildings undergoing major renovation (greater than 50%) has averaged 700,000 gross square feet, increasing annually by 95,000 square feet. The split is nearly even

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* The frequency of renovation for wood and wood-frame and masonry buildings may be affected by the fact that many institutions use them as temporary space, renovating them as different tenants move in and out.

between academic and auxiliary space. Because of a sharp increase in rehabilitation of academic space, renovated buildings accounted for 1,800,000 gross square feet in 1968, 300,000 more than expected. Using the trend indicated by a linear regression (the correlation is quite high - greater than 0.8) and starting in 1970, we can expect annual ; renovation of buildings totalling 880,000 gross square feet of academic space and 710,000 gross square feet of auxiliary space, with annual increases of 56,000 and 41,000 gross square feet, respectively. Using this projection, we may expect buildings undergoing major renovation in the 1970's to account for eleven million gross square feet of academic space and nine million gross square feet of auxiliary space.

Data were collected on expected dates of building demolition over the next fourteen years. There is progressively less space scheduled for demolition through this period, a trend that probably reflects increasingly uncertain plans for more distant dates. At present, 885,000 gross square feet of academic space and 265,000 gross square feet of axuiliary space are scheduled for demolition. But more useful figures are stated in terms of 1969 and the early 1970's; a predicted 130,000 gross square feet of academic space and 50,000 gross square feet of auxiliary space. will be razed annually, yielding 1,300,000 and 500,000 gross square feet to be demolished during this decade.

Gross Area

The average annual net addition of gross area over the last 22 years has been 1.1 million square feet.[6/] Because an average of 780,000 square feet currently is razed each year, the actual average addition of space (by construction, purchase, lease, etc.) has been above 1.9 million square feet per year.

A second-degree rather than a linear regression best fits these data. The addition of new area accelerated in both the mid-1950's and the early 1960's. In the late 1940's and early 1950's, 0.6 million square feet were added annually. With the enrollment increases that followed the Korean War and the stabilization of the economy, annual increases nearly doubled to 1.2 million square feet and remained at that level into the early 1960's, when they doubled again to 2.2 million gorss square feet. Deducting razed area, we find that the annual increment becomes 2.4 million (1.4 million academic) square feet.

It should be noted, however, that construction has decelerated in recent years. In 1967-68, for example, the academic area increment dropped from 1.4 million square feet to 0.9 million square feet. This deceleration was the product of price inflation and reduced government funding of educational construction.

6/ Multiply by 0.56 to convert to academic space.

Construction Costs

Over the last forty years construction costs have increased for both academic and auxiliary space. The cost of constructing academic space generally has been higher than that of constructing auxiliary space; during 1960-1968, academic space cost an average of $25.3 per gross square foot, while auxiliary space cost $20.9. Estimating 1940 costs as approximately $10.0 per square foot for both academic and auxiliary space, we see that the former have increased six to seven percent more than inflation, while the latter have decreased by about twelve percent (in 1940 dollars). Some fluctuation, though, has occurred. From the 1950's to the 1960's, construction costs for academic space increased some six percent more than inflation.[7/] Trends during the 1960's indicate that costs are increasing rapidly, about $.7 per year per gross square foot. When this rate is applied to the 1970's, the average costs during that decade should be about $33.0 and $28.6 per gross square foot of academic and of auxiliary space - an increase of about 25% and 30%, respectively. Unfortunately, these figures are not reliable, for costs have jumped sharply, rather than steadily since 1965. To compute construction costs for the 1970's, therefore, we must go beyond simple analysis of cost trends based on our data.

The bar graphs (figure 3) based on our data show construction costs by decade through 1968 for academic and auxiliary space. We wish to project average 1970-79 construction costs for both kinds of space; to do this, we will use a year by year history of general building costs from

7/ World Almanac, 1967, "Wholesale Price Index", p. 178

1932-1971[8/] and a cost differential for Boston equal to 8.4%.[9/] The identical line graphs of figure represent general building costs that have been standardized by setting the 1964 cost index at 23.0. As the graphs show, these costs correspond very well with educational construction costs, so it is reasonable to find educational construction costs for 1970-1979 by projecting general building costs and using the 8.4% cost differential for Boston.

We first must find the year of the 1970's in which the projected cost equals the average cost for the decade. We shall use the general formula for continuous discounting:[10/]

$$C = C_0 e^{rt}$$

where C is the cost at time t, C_0 is the initial cost, and r is the discount rate. Since our cost differential is .084, our formula for cost projection is

$$C = C_0 e^{.084t}$$

Let x be the year in which costs are average for the decade. Then

$$1/2 \int_0^{10} e^{.084t} dt = \int_0^{x} e^{.084t} dt$$

or

$$1/2\,(.084)\,(e^{10(.084)} - 1) = (1/.084)\,(e^{.084x} - 1)$$

$$(e^{.84} + 1)/2 = e^{.084x}$$

$$x = 6.1$$

8/ Engineering News Record, March 20, 1969, pp. 96-97. Note the three-year discrepancy between these data and those we obtained from the facilities inventory. This is because building contracts (used to compute general building costs) are signed three years before payment is made for completed construction (used to compute building costs for academic and auxiliary space).

9/ Architectural Record, April, 1970, p. 90.

10/ Continuous discounting is appropriate because a cost differential is available.

Thus the projected cost for 1976, 1 will be the average cost for 1970-79. To find the projected cost for 1976. 1, we have C=Cost for 1970=27. 0 and t=6. 1. Using our formula for cost projection, we get:

$$C_{average} = (27.0)(e^{(.084)(6.1)}) = 45.1$$

To find average construction cost for academic space, we multiply this figure by a correction factor (25. 3/23. 0), the average construction cost of academic space for 1970-68 (bar graph) divided by the average general building cost for the same period (line graph). Thus:

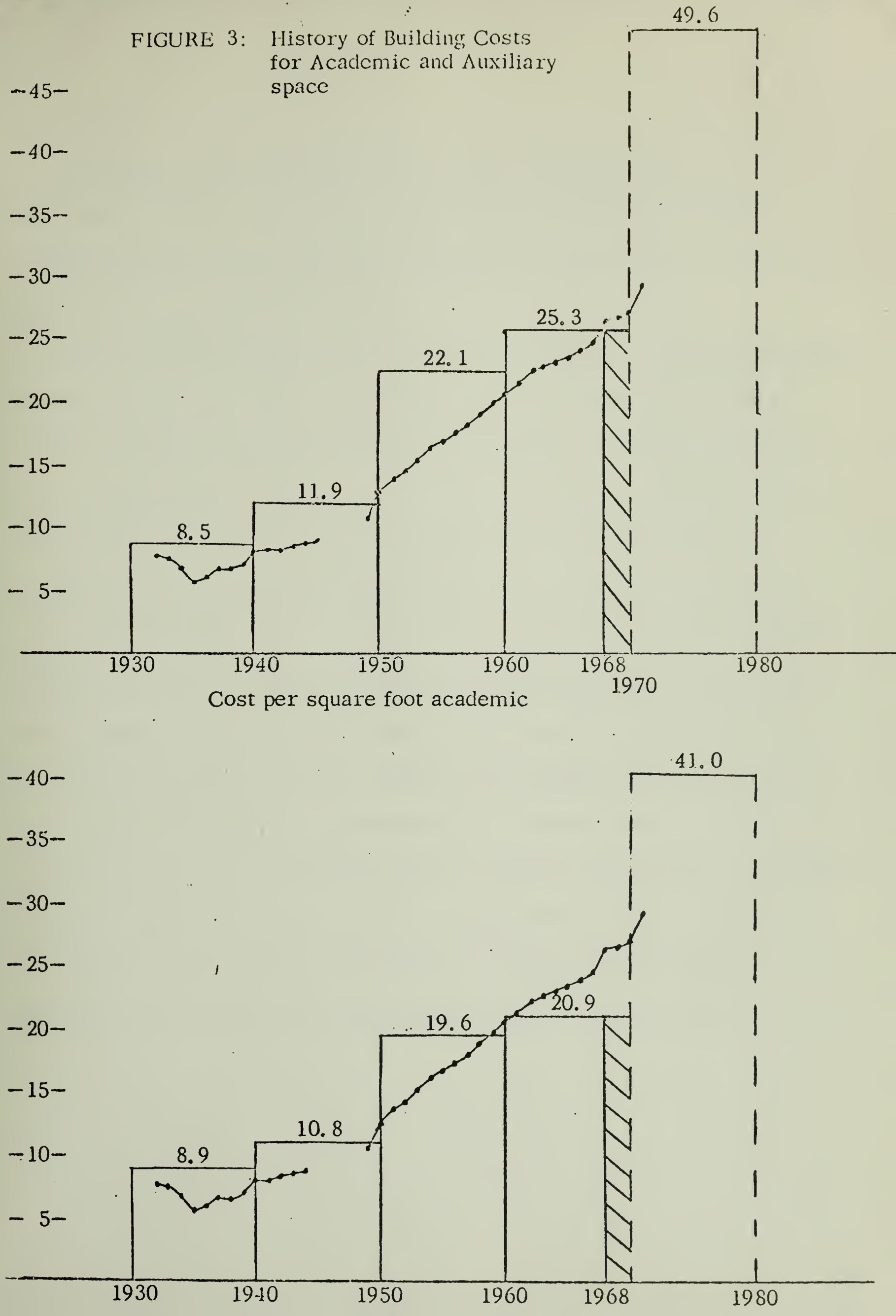
Projected average construction cost for academic space 1970-1979 = (25. 3/23. 0) 45. 1 = 49. 6.

And, using a (20. 9/23. 0) correction factor for auxiliary space,

Projected average construction cost for auxiliary space 1970-1979 = (20. 9/23. 0) 45. 1 = 41. 0.

These figures are average costs for buildings constructed in 1970-1979; average costs for buildings contracted in 1970-1979 would be significantly higher.

FIGURE 3: History of Building Costs for Academic and Auxiliary space



Enrollment

Enrollment, like construction, has accelerated sharply twice over the last twenty-two years: after the Korean War and during the early 1960's. In 1968, total head-count enrollment (parttime-fulltime, graduate-undergraduate) was 261,000, up 70,000 from 1966.

Construction has lagged behind enrollment increases. With high correlation (-0.881), for example, the gross academic space per student has fallen off. In 1950, there were 255 gross square feet of academic space per student, but by 1968 this ratio had dropped to 140. At this rate, in 25 years there will be 15 gross square feet (or 9 NASF) of academic space for each student. A school, of course, could never operate with such a ratio; the result will be severe restrictions on the number of qualified students admitted to institutions of higher education. In light of the large enrollment increases of recent years, this concurrent slowdown in construction is particularly distressing.

At the 95% confidence level, present trends indicate an annual decrease of at least 3.7 and at most 6.5 gross square of academic space per student. Based on construction and enrollment rates of the past two decades, the expected annual decrease of academic space is 5.1 gross square feet per student.

Actually, the situation is much worse. The linear regression of enrollment does not do justice to the exponential growth of the number

of qualified people seeking entrance to colleges and universities. The Higher Education Enrollment Study for Massachusetts (January, 1969) showed the disparity between institutional plans to accomodate students and enrollment projections based on population statistics:

Year	Enrollment Projections	Institutional Expectations	Difference (demand greater than supply)
1969	287,000	267,000	-20,000
1975	411,000	351,000	-60,000
1980	524,000	411,000	-113,000

"These differences are obviously quite substantial; they indicate that more than one out of every five potential students projected to enter an institution of higher education in 1980 could be turned away for lack of space." 11/

At the present rate of construction (using 1966-1968 figures - 1,000,000 and 800,000 gross square feet of academic and auxiliary space annually), gross area in the state will have increased by 12.6 million square feet to total 77.7 million square feet by 1975. By 1980, at the same rate of construction, gross area in the state will have increased by another 9.0 million gross square feet to total 86.7 million square feet. The increases in area to 1975 and 1980 represent, respectively, 20% and 14% of the 1968 total gross area figure.

11/ Higher Education Enrollment Study for Massachusetts, p. 19. These figures are head-count fulltime-parttime and graduate-undergraduate.

Institutional expectations for enrollment for the years 1975 and 1980 indicate increases over 1968 figures of 34% and another 25%. Present plans indicate a 1975 area per student figure of 221 gross square feet (141 NASF per student); by 1980 this ratio will have dropped to 196 gross square feet (125 NASF per student). The 1968 level was 250 gross square feet (161 NASF per student).[12/]

In itself, this decrease is no disaster; other states operate with lower overall ratios. But the decrease does not account for qualified students who will be turned away. To accomodate them, even at the lowered ratios, thirteen million additional gross square feet must be added before 1975, and another eleven million by 1980.

12/ Reliable assignable area figures are obtained by multiplying the gross area by 0.64.

Projected Costs

Stated in 1970 dollars, construction costs based on buildings contracted in 1965 and constructed in 1968 ran about $29.5 per gross square foot of academic space and $24.5 per gross square foot of auxiliary space. The ratio of academic to auxiliary space has been 1.0/0.8, and we assume this ratio will persist. During the 1970's, we expect renovation to affect buildings with 11 million gross square feet of academic and 9 million gross square feet of auxiliary space. In addition, 130,000 gross square feet of academic space and 50,000 gross square feet of auxiliary space are razed annually, and these figures are expected to remain fairly constant.

Charts I and II show construction needs and costs for 1970-79. We have computed space needs by multiplying existing gross square feet of academic and auxiliary space per student for public and private institutions by (1) institutional enrollment expectations and (2) Board of Higher Education enrollment projections.[13/] Existing gross square feet per student ratios are based on the highest available enrollment counts for 1968, which are head counts rather than full-time student equivalent figures. These consequently lower ratios serve to minimize the space requirements based on Board of Higher Education enrollment projections. We have made no attempt to meet na-

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13/ In 1968-80, institutions expect enrollment to grow from 261,000 to 411,000 - an increase of 150,000. But according to population statistics, the Board of Higher Education projects a 1980 enrollment demand of 524,000, or 113,000 more than institutions expect. We have extrapolated for this 113,000 increase of Board of Higher Education projections over institutional expectations in three ways:

1. extending the public/private mix of the student increase indicated by institutional expectations;
2. extending the mix that will be achieved when enrollment has reached 411,000;
3. assuming that the extra 113,000 projected by the Board of Higher Education will be accomodated by public institutions alone.

tional guidelines for gross square feet per student, particularly in public institutions.[14/] What emerges, then, is a conservative estimate of minimum construction requirements over the next ten years.

Space requirements are divided into academic and support facilities (chart I) and auxiliary facilities (chart II) because the funding of these types of space differs. Academic and support facilities depend on private gifts, federal grants, and state and local appropriations. Auxiliary space is funded partially by student fees, building associations, and building authorities, and partially by private enterprise operating with the federal interest subsidy. The mix of these sources is a function of student ability to pay for portions of auxiliary facilities, and the dimensions of building programs for auxiliary space depend on institutional policy and the character and location of new campuses. Building programs for academic and support facilities are a linear function of enrollment, so we can project them with confidence.

For the 1970's, we have provided two sets of anticipated construction costs per square foot for both academic and auxiliary space. The lower of the two ($50 for academic and $41 for auxiliary) represents average construction costs for the decade based on projected inflation and assuming that construction begins immediately. It is important to note, however, that even a slight error in our projected inflation rate could increase real costs by hundreds of millions of dollars. More important is the fact that a three year lag in construction will add almost 30% to the average construction cost per gross square foot; and such a lag is likely, given the time that institutions

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14/ In 1968, many public institutions operated in old high school and rented facilities.

will take to respond to the needs that this report projects. To show the net effects of such a lag, we have provided a higher set of figures ($64 for academic and $53 for auxiliary space) and carried out a duplicate set of computations based on them. These costs are for building design and construction only. To the basic construction needs for enrollment increases, we added predicted replacement and renovation needs based on projections from the 1968 facilities inventory. Generally, equipment costs add an average of 15% to total construction costs fro academic space and 10% to costs for auxiliary space. We added these percentages and then increased the totals by 25% to account for additions to utility systems; service roads, walks, and lighting; surface parking; and campus development and land acquisition.[15/]

The demand of Massachusetts residents combines with national demand on Massachusetts' esteemed institutions of higher education to produce dramatic projections for even minimum construction costs. As chart III shows, figures range from $3.8 billion ($3,842,000,000) for meeting 150,000 of the projected enrollment increase at public and private institutions and the remaining 113,000 at public institutions, and assuming that construction begins immediately, to $5.9 billion ($5,878,000,000) for meeting the projected enrollment increase at the public/private mix that will be achieved at the 411,000 level and accounting for a three year construction lag. Note that these figures are based on minimal to below normal area per student ratios and therefore are understatements. Although such understate-

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15/ No estimates were made for unusual construction costs due to site, urban construction, public transportation, highway improvements, and additional public utility services such as water, sewage, etc.

ment is partially offset by facilities completed or funded between 1968 and 1970, and by the existing facilities of non-reporting institutions, even the most extensive institutional construction plans now under consideration will fail to meet the demand, for the total 1968-1980 enrollment increase is equal to half the population of Boston.

Our estimates are basic and conservative; the real costs will be greater. Yet present state and private construction plans will fail to accomodate 113,000 students by 1980, and even more in the ensuing decade. In light of these very real projections, public and private institutions will have to reconsider their present policies.

CHART I - ACADEMIC AND SUPPORT SPACE

	STUDENT INCREASE			GROSS SQUARE FOOTAGE INCREASE			TOTAL FUNDS REQUIRED					
	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total
(A) INSTITUTIONAL EXPECTATIONS OF GROWTH FROM 261,000 TO TOTAL ENROLLMENT OF 411,000							(At $50/Gross Sq. Foot)			(At $64/Gross Sq. Foot)		
							($3764/stud.)	($8088/stud.)		($4812/stud.)	($10372/stud.)	
New Resources	106,810	42,903	149,713	8,036,000	6,946,000	14,982,000	$402,000,000	$347,000,000	$749,000,000	$514,000,000	$445,000,000	$959,000,000
Replacement						1,300,000			65,000,000			83,000,000
Renovation						11,000,000	(At $32.00/Gross Sq. Ft.)		320,000,000	(At $40.95/Gross Sq. Foot)		460,000,000
Total Construction									$1,166,000,000			$149,000,000
Equipment (15%)									175,000,000			224,000,000
Total Project									$1,341,000,000			$1,716,000,000
Land, Utilities, Etc. (25%)									335,000,000			429,000,000
Total Construction Program - 150,000 Increase to 411,000									$1,676,000,000			$2,145,000,000
(B) ENROLLMENT PROJECTIONS INCREMENT OVER TOTAL ENROLLMENT (A) - 113,000												
1-At Mix of Student Increase (A)-(71% Public, 29% Private)							($3764/stud.)	($8088/stud.)		($9812/stud.)	($10372/stud.)	
New Resources	80,500	32,500	113,000	6,057,000	5,262,000	11,319,000	$302,000,000	$263,000,000	$565,000,000	$387,000,000	$337,000,000	$724,000,000
Equipment (15%)							45,000,000	40,000,000	85,000,000	58,000,000	50,000,000	108,000,000
Land, Utilities, Etc. (25%)							87,000,000	76,000,000	163,000,000	111,000,000	97,000,000	208,000,000
Total Construction Program (B-1)									$813,000,000			$1,040,000,000
Total Construction Program (A)									1,676,000,000			21,450,000,000
Total Construction Program Estimate - Growth From 261,000 To 524,000 (A) + (B-1)									$2,489,000,000			$3,195,000,000
2-At Mix Of Total Enrollment (A) - 46% Public, 54% Private							($3764/stud.)	($8088/stud.)		($4812/stud.)	($10372/stud.)	
New Resources	51,980	61,020	113,000	3,920,000	9,879,000	13,799,000	$195,000,000	$494,000,000	$690,000,000	$250,000,000	$633,000,000	$883,000,000
Equipment (15%)							29,000,000	74,000,000	103,000,000	38,000,000	95,000,000	133,000,000
Land Utilities, Etc. (25%)							56,000,000	142,000,000	198,000,000	72,000,000	182,000,000	254,000,000
Total Construction Program (B-2)									$991,000,000			$1,270,000,000
Total Construction Program (A)									1,676,000,000			2,145,000,000
Total Construction Program Estimate - Growth From 261,000 To 524,000 - (A) + (B-2)									$2,667,000,000			$3,415,000,000
3-At 100% Public Mix							($3764/stud.)			($4812 stud.)		
New Resources	113,000		113,000	8,052,000		8,052,000	$425,000,000		$425,000,000	$544,000,000		$544,000,000
Equipment (15%)							64,000,000		64,000,000	82,000,000		82,000,000
Land, Utilities, Etc. (25%)							122,000,000		122,000,000	157,000,000		157,000,000
Total Construction Program (B-3)									$611,000,000			$793,000,000
Total Construction Program (A)									1,676,000,000			2,145,000,000
Total Construction Program Estimate - Growth From 261,000 to 524,000 - (A) + (B-3)									$2,287,000,000			$2,928,000,000

CHART II - AUXILIARY SPACE

	STUDENT INCREASE			GROSS SQUARE FOOTAGE INCREASE			TOTAL FUNDS REQUIRED					
	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total
(A) INSTITUTIONAL EXPECTATIONS OF GROWTH FROM 261,000 TO 411,000 TOTAL ENROLLMENT							(At $41/Gross Sq. Foot)			(At $53/Gross Sq. Foot)		
New Resources	106,810	42,903	149,713	6,903,000	7,117,000	14,020,000	($2650/stud.) $283,000,000	($6806/stud.) $292,000,000	$575,000,000	($3427/stud.) $366,000,000	($8787/stud.) $377,000,000	$745,000,000
Replacement						500,000			21,000,000			27,000,000
Renovation						9,000,000	(At $26.25/Gross Sq.Ft.)		236,000,000	(At $33.95/Gross Sq. Ft.)		306,000,000
Total Construction									$832,000,000			$1,076,000,000
Equipment (15%)									83,000,000			108,000,000
Total Project									$915,000,000			$1,184,000,000
Land, Utilities, Etc. (25%)									229,000,000			296,000,000
Total Construction Program - [illegible] Increase in Additional Students									$1,144,000,000			$1,480,000,000
(B) ADDITIONAL STUDENTS ACCORDING TO ENROLLMENT PROJECTIONS (GROWTH FROM 261,000 TO 524,000 TOTAL ENROLLMENT)												
1-At Mix Of Student Increase (71% Public, 29% Private)												
New Resources	80,500	32,500	113,000	5,203,000	5,391,000	10,594,000	($2650/stud.) $213,000,000	($6806/stud.) $221,000,000	$434,000,000	($3427/stud.) $276,000,000	($8787/stud.) $286,000,000	$562,000,000
Equipment (10%)							21,000,000	22,000,000	43,000,000	28,000,000	29,000,000	57,000,000
Land, Utilities, Etc. (25%)							59,000,000	61,000,000	120,000,000	76,000,000	79,000,000	155,000,000
Total Construction Program (B-1)									$597,000,000			$774,000,000
Total Construction Program (A)									1,144,000,000			1,480,000,000
Total Construction Program Estimate - Growth From 261,000 to 524,000 - (A)+(B-1)									$1,741,000,000			$2,254,000,000
2-At Mix Of Total Enrollment (A) - 46% Public, 54% Private												
New Resources	51,980	61,020	113,000	3,359,000	10,120,000	13,479,000	($2650/stud.) $138,000,000	($6806/stud.) $ 415,000,000	$553,000,000	($3427/stud.) $178,000,000	($8787/stud.) $536,000,000	$714,000,000
Equipment (10%)							14,000,000	42,000,000	56,000,000	18,000,000	54,000,000	72,000,000
Land, Utilities, Etc. (25%)							38,000,000	114,000,000	152,000,000	49,000,000	148,000,000	197,000,000
Total Construction Program (B-2)									$762,000,000			$ 983,000,000
Total Construction Program (A)									1,144,000,000			1,480,000,000
Total Construction Program Estimate- Growth From 261,000 to 524,000 - (A) + (B-2)									$1,906,000,000			$2,463,000,000
3-At 100% Public Mix												
New Resources	113,000		113,000	7,340,000		7,340,000	($2650/stud.) $299,000,000		$299,000,000	($3427/stud.) $387,000,000		$387,000,000
Equipment (10%)							30,000,000		30,000,000			39,000,000
Land, Utilities, Etc.(25%)							82,000,000		82,000,000			107,000,000
Total Construction Program (B-3)									$411,000,000			$553,000,000
Total Construction Program									1,144,000,000			1,480,000,000
Total Construction Program Estimate - Growth from 261,000 to 524,000 - (A) + (B-3)									$1,555,000,000			$2,013,000,000

	Academic and Support Space	Auxiliary Space	TOTAL	
(A) INSTITUTIONAL EXPECTATIONS OF GROWTH FROM 261,000 TO TOTAL ENROLLMENT OF 411,000	$1,676,000,000	$1,144,000,000	$2,820,000,000	LOW (1970-1979)
	$2,145,000,000	$1,480,000,000	$3,625,000,000	HIGH (3 year lag)
(B) ENROLLMENT PROJECTIONS INCREMENT OVER (A) — 113,000	$813,000,000	$597,000,000	$1,410,000,000 +2,820,000,000 $4,230,000,000	LOW (1970-1979)
1-At mix of student increase(A)	$1,040,000,000	$774,000,000	$1,814,000,000 +3,625,000,000 $5,439,000,000	HIGH (3 year lag)
2 - At mix of total enrollment (A)	$991,000,000	$762,000,000	$1,753,000,000 +2,820,000,000 $4,573,000,000	LOW (1970-1979)
	$1,270,000,000	$983,000,000	$2,253,000,000 +3,625,000,000 $5,878,000,000	HIGH (3 year lag)
3 - At 100% public mix	$611,000,000	$411,000,000	$1,022,000,000 +2,820,000,000 $3,842,000,000	LOW (1970-1979)
	$793,000,000	$533,000,000	$1,326,000,000 +3,625,000,000 $4,951,000,000	HIGH (3 year lag)

CHART III

Financial Summary of Charts I and II

APPENDICES

APPENDIX A.

A DESCRIPTION OF THE FIPS COMPUTER SYSTEM

INTRODUCTION

Five separate programs comprise the Facility Inventory Project System, (FIPS), two programs in Phase I, three in Phase II. The programs are as follows:

PHASE I

EDIT

UPDATE

PHASE II

LISTING

MATRICES

PLOTS

The Phase I programs are used to bring new data into the system and produce a new master file. This file is, in turn, input to each of the Phase II programs. The following diagram shows the relationship between the five programs, and the data files that serve as input and output to each.

The new master file will, in turn, become the old master file when it is desired to make corrections to it, and another new master file will be produced.

THE FIVE PROGRAMS

Edit:

The edit program reads in the correction cards, validates the data, and produces a tape that will serve as input to the update program. This tape is referred to as the transaction file. It also creates two lists. The first is a list of the cards that it found to be in error. These cards will be listed in the same format and in the same order as they appeared in the deck of correction cards. An asterisk beneath a field indicates that it is in error (the data itself is incorrect, or is misplaced within the field), and the letter M indicates that that field is missing. The user should examine this list and decide if these cards should be corrected and the edit program re-run. A card that has missing fields, but no field in error, will not show up in this list.

The second list shows the new data as it will appear on the master file. The data has been sorted so the records appear in the order of ascending institution, ascending building number within institution, and room sequence within each building. The edit assigns new rooms sequence number 9999, so that they appear at the end of each building. (The update program will assign them more appropriate sequence numbers). This list, saved from each run of Phase I, can serve as a permanent record of changes made to the master file. The format of these records differs from that of the correction card, and

is, instead, in the format used internally by the program. See Appendix A and B for the correction card format and the internal format. The records for cards that the Edit Program found in error do not appear in this list-ing exactly as they will appear on the master file. The Edit program has added a 1 to the left-most position of numeric fields of room records to indicate to the update program that these fields were in error. Building characteristic records are followed by a sequence 3 record to indicate errors. It should be noted that the introduction of two building cards for the same building, or two buildings with the same building number, will cause later reports to be inaccurate. It is suggested, therefore, that the user peruse this list of records carefully, and verify that no such duplicates exist.

The Edit Program actually consists of 3 programs. The first, and largest performs the editing function. A second job step calls upon the standard 360 OS soft package to sort the data records. The third job step lists the sorted records. This third program is written in Utility Coder, a CCA proprietary program.

Update Program:

The Update Program uses the output tape of the edit program and corrects the old master file, creating a new one. Rooms, buildings, and institutions are appropriately added, deleted, or replaced. An option card, set up by

the user, controls the programs operation. The format of the card is as follows:

Column 5	M indicates that there will be a master file for this run
Column 6	T indicates that there is a transaction file
Column 7	R indicates that there will be a state summary report
Column 8-15	The date in the following format: 09/22/69

In almost all cases, there will be both a master file and a transaction file. If, however, the user wants to start from scratch, i.e., he does not intend to update his current master file, but wishes instead to create a new one, entirely from cards, then he will use the edit program to produce the transaction file, and run the update without a master file. If the user would like to produce a report, but does not want to correct the master file, he would just run the update program with his master file and without a transaction file.

A report will be printed for each institution for which an institution record exists on the transaction file, i.e., for each institution card submitted to the edit program. The state summary report will be produced only if an "R" appears in column 7 of the option card.

The Plot, Listing and Matrix Programs:

These programs produce the graphs and reports described in the Document

"Derived Data Projections" Draft June 22, 1969. They use the newest master file as input, and can be run in any order.

The Plot Program produces visual displays and statistical analyses of correlations on the state level. Year of construction, demolition, and renovation of the building in the state are compared to cost and size in various combinations.

The Listing program creates lists of data on building, campus, and state levels. These lists concern gross, assignable, and research area, as well as construction and financial information.

The Matrix Program displays building, campus, and state wide correlations in table format. The data dealt with in this fashion include utilization, construction, financial, and enrollment information. Also created by the Matrix Program is a table for each school that can be copied directly onto the Hegis Form.

RUNNING THE PROGRAMS

Job control cards are placed at the beginning and end of a program that serve to describe to the computer the type of program to be run and the various input and output files. These cards are installation dependent, i.e., they will have to be changed if the program is to be run on a diff-

erent computer. All five programs require that the computer be equipped to handle Fortran IV, level G. The largest of the five, the Matrix Program, requires 316 K core. The Plot Program makes use of the SC 4020 Plotter, a feature of the Avco installation. The production of the full list of all correction records by the edit program, requires that computer have access to Utility Coder, a requirement fulfilled by Phillip Hankins but not by Avco. The Edit Program is now set up to run at Phillip Hankins, and the remaining four programs at Avco. The Avco programs are set up to produce four part printed output.

In setting up the program to run, the user is concerned with two matters. They are described separately below.

1. The placement of the data cards in the program deck. The user's correction cards are input to the edit program, and should be placed between the two red cards. If there are a lot of correction cards, the latter part of the program deck may be put into another box. Be sure to number the boxes to indicate to the operator the order in which the boxes are to be read. The first box should contain the first part of the program deck (up to and including the first red card), and as many correction cards as will fit. As many boxes as necessary to contain the remaining correction cards, and the last box ends with the remainder of the program deck (from the second red card on).

The update program requires the option card described above. It should be placed between the two red cards at the end of the program.

2. Changing the job control cards to reflect changes in the tapes used as input and output. Each time the system is run, such changes are likely to occur. The new master file will probably become the old master file for the update program, and a new master file produced. It is this tape that will be used to run the Phase II programs. The job control cards that may have to be changed appear near the end of each deck and are blue. The particular field on that card that may be changed is the six characters that follow the words VOL-SER-. The six alphanumeric characters that are put in that space usually appear written on the outside of the tape itself. There is one of these cards in each program for each tape that will be used as input or output. The blue cards in each program refer to:

Edit Program

1st blue card - the transaction tape

2nd blue card - the transaction tape

Update

1st blue card - the transaction tape

2nd blue card - the old master tape

3rd blue card - the new master tape

Plot

the new master tape

Listing

the new master tape

Matrix

the new master tape

The user having set up the decks as described above, will contact the appropriate computer installation. He will have to fill out a form to run the program, and can receive help in doing this at the installation.

APPENDIX A - 1. PUNCHED CARD LAYOUTS

I INSTITUTION CARD

Card Columns	Contents	Format
1-3	Institution Number	right adjusted, zero filled
4-43	Institution Name	left adjusted, blank filled
44-47	Institution Name	right adjusted, blank filled
48-52	enrollment	right adjusted, zero filled
53	1=public 2=private	
79	"D" to delete institution	
80	"I"	

II BUILDING CHARACTERISTICS

1. Building Name Card

1-3	Institution Number	right adjusted, zero filled
4-6	Building Number	right adjusted, zero filled
7-31	Building Name	left adjusted, blank filled

2. Building Data Card

1-3	Institution Number	All the fields on this card are right adjusted and zero filled, except for LS and ID (see below)
4-6	Building Number	
7	Ownership Code	
8	Degree of Graduate Program	
9-10	Type of School	

Card Columns	Contents	Format
11-12	Location	
13-16	Year Initially Occupied	
17-20	Year Constructed	
21-24	Year Rehabilitated	
25-28	Year Scheduled to be Demolished	
29	Type of Construction	
30-31	Number of Floors	
32	Condition	
33	Fallout Shelter	
34	Air Cooling	
35-39	Building Cost, or LS Coding*	
40-44	Equipment Cost, or LS Colding or IB Coding*	
45-49	Estimated Value of Building, or IB Coding*	
50-56	Gross Area (Square Feet)	
57-58	Code Number (a)	
59-63	Amount (a), or LS Coding	
64-65	Code Number (b)	
66-70	Amount (b), or LS Coding	
71-72	Code Number (c)	
73-77	Amount (c), or LS Coding	
79	D for delete	
80	"B"	

*LS Coding: The first two columns of the field contain"LS"; the last three columns contain the number of the Building for which the Lump Sum amount was coded.

** IB Coding: The first two columns (40-41) contain "IB" indicating that the Equipment Cost is included in the Building Cost.

3 Building Data Continuation Card

When the sources of the building's funding exceed three, one or more continuation cards are required.

Card Columns	Contents	Format
1-3	Institution Number	All fields right adjusted, zero filled, except for LS and IB (see above)
4-6	Building Number	
57-77	As needed, according to format specified for Building Data Card	
79	Continuation Number (e.g., "1" for 4th-6th funds source; "2" for 7th-9th funds source, etc.)	
80	"B"	

III ROOM CARD

1-3	Institution Number	right adjusted, zero filled
4-6	Building Number	right adjusted, zero filled
7-11	Room Number	right adjusted, zero filled
12-31	Institutional Name of Unit	left adjusted, blank filled
32-39	Institutional Code	

40-43	Organization Unit and Subject Field Code	right adjusted, zero filled
44-58	Institutional Name of Unit	left adjusted, blank filled
59-61	Room Type Code	right adjusted, zero filled
62-65	Stations	right adjusted, zero filled
66-71	Net Assignable Area	right adjusted, zero filled
72-74	Research Percent	right adjusted, zero filled
79	"D" for delete	
80	"R"	

APPENDIX A - 2. INTERNAL RECORD LAYOUT

I INSTITUTION RECORD

POSITION	CONTENTS
1-3	Institution Number
4-6	Building Number
7-10	Sequence Number = 0
11-50	Institution Name
51-54	Type of Institution
59-63	Number code for institution type
64-68	enrollment
69-73	1=public 2=private

II BUILDING CHARACTERISTICS

1. Building Name

1-3	Institution Number
4-6	Building Number
7-10	Sequence Number = 1

2. Building Data Record

1-3	Institution Number
4-6	Building Number

7-10	Sequence Number = 2
11-38	Same Card Building Date Card Columns 7-34
53-54	LS/IB for building cost
55-56	LS/IB for equipment cost
57-58	LS/IB for estimated value
59-63	Building Cost
64-68	Equipment Cost
69-73	Estimated Value
74-80	Gross Area

3. Building Data Record Continuation

1-3	Institution Number
4-6	Building Number
7-10	Sequence Number
47-48	LS/IB for source 1
49-50	LS/IB for source 2
51-52	LS/IB for source 3
53-54	Source code 1
55-56	Source code 2
57-58	Source code 3
59-63	Fund amount, source 1
64-68	Fund amount, source 2
69-73	Fund amount, source 3

III. ROOM RECORD

POSITION	CONTENTS
1-3	Institution Number
4-6	Building Number
7-10	Sequence Number = 4
11-15	Room Number
16-35	Institution Name of Unit
36-43	Institution Code
44-58	Institution Name of Room
59-63	Origin Unit and Subject Field
64-68	Stations
69-73	Research Percentage
74-80	Net Area
81-84	Room Type

APPENDIX A - 3. AUXILIARY PROGRAMS

Several auxiliary programs were written during the checking out of the FIPS computer system. These may prove useful to the user and are described below. They are both written in Utility Coder, and therefore must be run at an installation equipped with this CCA proprietery program. The programs are now set up to run at Phillip Hankins.

1. Master File Summary Report

This program will make a list of an institution record, and all building names and characteristic records. This listing can be very useful in determining quickly the current state of the master file. Estimated run time is about 5 minutes.

2. Removal of Duplicate Building Records

This program will eliminate building name and building characteristic records if two or more such records exist for the same building number. Estimated run time is about 7 minutes.

APPENDIX A - 4. STEP BY STEP PROCEDURE

The following presumes that the reader is already familiar with the rest of this document, especially, the section entitled 'Running the Programs.' It is intended to be used as a check list.

1. Determine corrections to be made to the master file, and have these key punched in format described in Appendix A. Include institution cards for those institutions that you wish to appear on the state report.

2. Place correction cards in the appropriate place in the Edit deck, and verify that the control card for the transaction file specifies the appropriate tape. Run the Edit program.

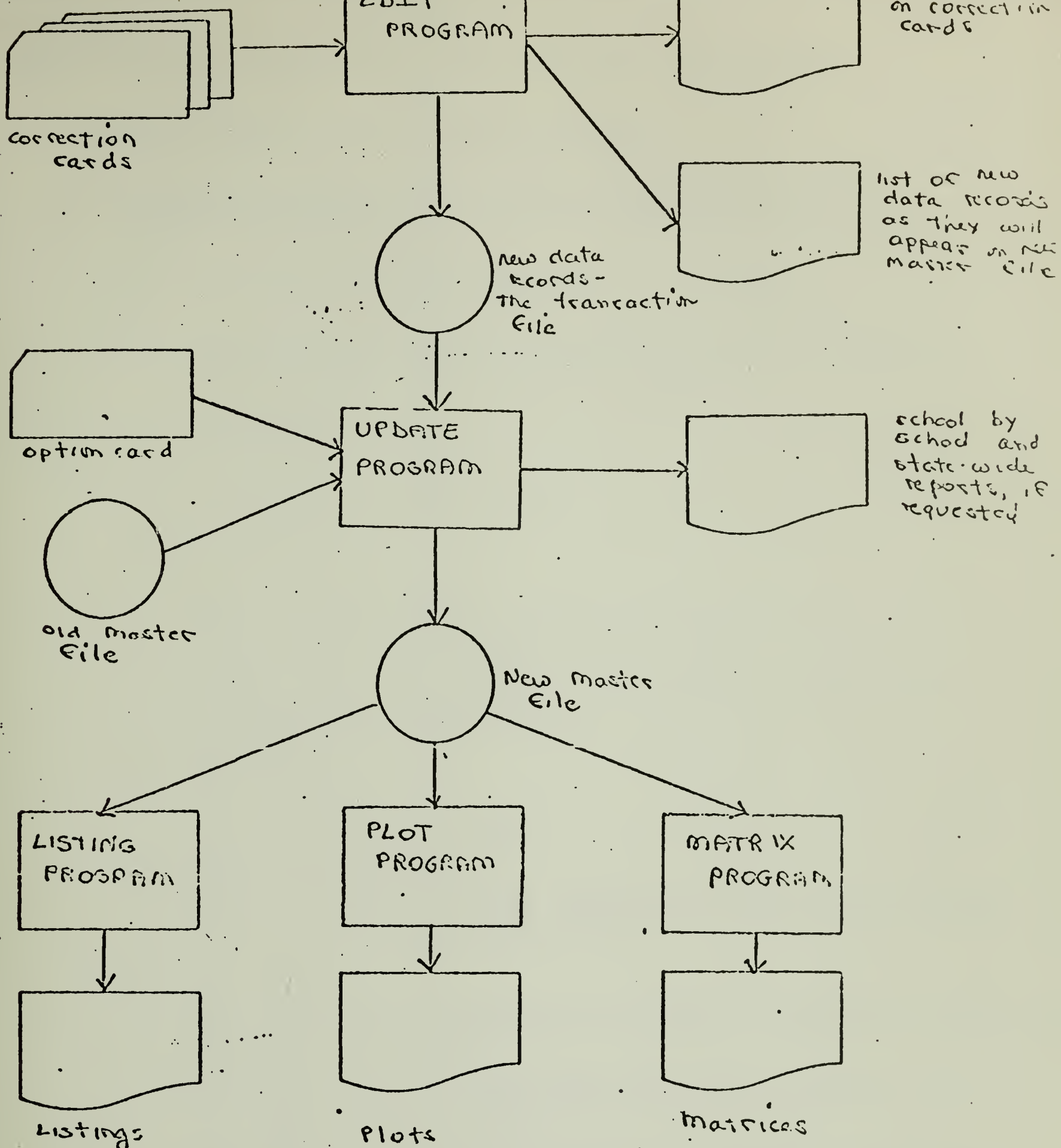
3. Examine list of errors on the correction cards. Decide whether these errors are extensive enough to warrant repunching of the card in question; and then re-running the Edit program.

4. Examine the list of all corrections, i.e., the list of the transaction file produced by the Edit program. Verify that you have, indeed made the changed that you have intended, to the master file. Verify that no duplicate records exist. Date this list and save it.

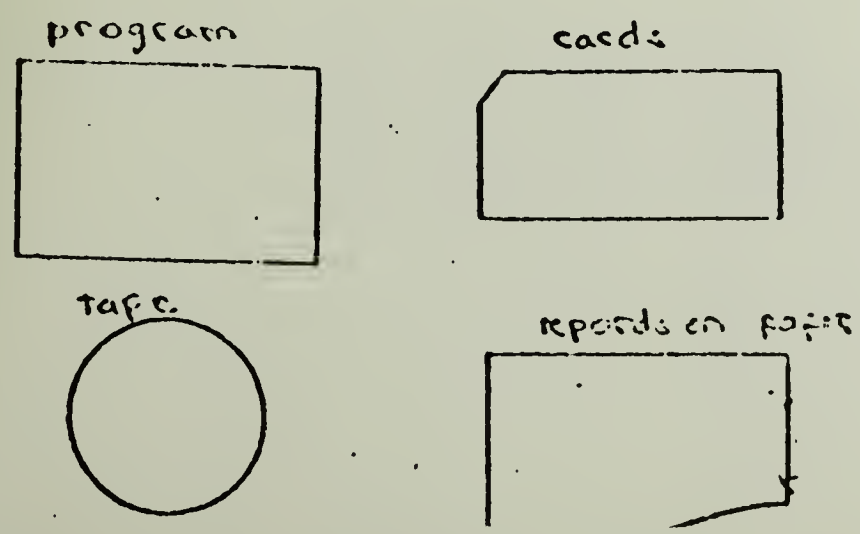
5. Punch option card for the Update program. Place in proper position in Update program deck. Change, if necessary, control cards so that they specify the appropriate tapes. Run the Update program.

6. Examine reports produced by Update

7. Run the Plot program, the Listing program, and the Matrix program, having first changed, if necessary, the control card in each program so that it specifies the new master file.



KEY:



arrow into a program indicates input

arrow out of program indicates output

APPENDIX B.
AN OUTLINE OF THE FIPS COMPUTER OUTPUT DATA

I. CAMPUS LEVEL - PART I - INPUT LISTING

A. For every building in use, the following information will be found for that building:

1. The institution number and name

2. Institution type (Federally designated codes: I-V for highest level offering and A-K for type of program)

3. Enrollment

4. The building number and name

5. Under Function

(a) Ownership code (1-8, owned, leased, etc.)
(b) Degree of graduate program (1-6, where 1 is none, 2 is 1% - 9%, etc., through 6 is 75% - 100%)
(c) Type of school (1-20 is any of a number of professional schools this building serves.
(d) Location

6. Under History

(a) Year initially occupied
(b) Year constructed
(c) Year of the most recent rehabilitation and/or modernization
(d) Year scheduled to be demolished

7. Under Design
(a) Type of construction (1-9 wood frame, reinforced concrete, etc.
(b) Number of floors
(c) Condition (1-5 "satisfactory" to "should be razed", etc.)
(d) Fallout shelter (1-4 as a description of the building in a national shelter survey)
(e) Percent air-cooled (1-6 where "1" is none through "6" is 75% - 100%)

8. Under Investment
(a) Cost of the building
(b) Cost of the equipment
(c) Estimated insurable value of the building

9. Gross Area

10. Under Sources of Funds

(a) Sources of funds (1-20 it includes sources from government, appropriations, taxes, foundations, loans, etc.)
(b) The amount of the Fund. This will be repeated if more than one source is involved.

B. Room by Room Inventory For The Building

1. Room Number

2. Under Organizational Unit:

(a) Institutional name of unit
(b) Institutional code (for institution's use)
(c) Organizational unit - Subject-Field Code (1110-9083)

3. Under Room Type

(a) Institutional name of room
(b) Room Type (110-999 and non-assignable codes)

4. Number of Stations

5. Net Assignable Area

6. Percentage Research

C. Total Net Assignable Area For Building.

D. After Last Building, Total NASF for Institution

II. CAMPUS LEVEL - PART II - MATRIX

A. For Every Building:

1. Data breakdown by organization and subject-field codes (Detailed 1110 - 9083) versus Room Type (general 100-900)

2. Each cell contains:

   (a) Number of rooms
   (b) Room NASF
   (c) Percent room NASF/building NASF
   (d) Number of stations
   (e) Room NASF/stations
   (f) percent research

3. Followed by Non-Assignable Area listing by Room type (10-40)

B. Same as above but carried to campus level with non-assignable area omitted

C. For every building:

1. Data breakdown by room-type (detailed 110-999) versus organizational unit and subject-field code (1000-9000)

2. Every cell contains same information as matrix A.

D. HEGIS Matrix: Campus level general Room Type vs. Organizational Unit, with each cell containing no. of rooms and NASF followed by non-assignable listings.

E. Data Breakdown by Type of School (1-20) versus Degree of Graduate Program (%) Each Cell Contains

1. Number of buildings, and

2. Combined NASF, followed below by:

3. Listing of type of school

4. Graduate area

5. % of total campus area

F. Building by Building Listing of:

1. Ratio of NASF to gross area

2. Gross area and % of campus total

3. Campus wide listing of area by room type

G. Construction Data:

1. Total Gross Area
2. Total NASF
3. NASF to Gross Area Ratio
4. Listing of contruction type with number of buildings and combined Gross Areas
5. Listing construction by decade, number of buildings, and Gross Areas
6. Scheduled year of demolition, number of buildings, and Gross Area with total Gross Area to be demolished cost.

H. Financial Data:

1. Total building costs
2. Equipment costs
3. Estimated value of buildings
4. Sources of funds listing, number of them, and combined amounts
5. Ownership codes listing, number of buildings, Gross Area, and value of each

I. Enrollment Data:

1. Total enrollment
2. NASF/student

III. STATE SUMMARIES - PART I - LISTING

A. Institutional Gross Areas by Federal institutional codes (I-II, A-K) and ownership code.

B. Gross Area of construction by decade

C. Assignable area detailed by Organizational Unit and Subject Field codes

D. Assignable area detailed by Room-Type

E. Statewide Gross Area, NASF, and NASF/Gross Area

F. Financial data:

1. Cost of buildings, cost of equipment, and present estimated value of building

2. Sources of funds, number of buildings, and amount

G. Ownership listing by number of buildings, amount and Gross Area

H. State enrollment, State NASF/state enrollment, standard deviation of that ratio

IV. STATE SUMMARIES - PART II - MATRIX PROGRAM

A. Data breakdown by institutional code (I-V) versus type of program codes (a-k). Each cell contains:

1. Number of schools

2. NASF

3. That NASF as a percentage of State NASF/number of schools as a percentage of the total number of schools

4. Percent of state enrollment/percent of total number of schools

5. Percent of state area/percent of state enrollment

6. NASF/student

B. Detailed Organizational-Unit Subject Field Code (1110-9083) versus general Room-Type (100-900). Each cell contains:

B. (continued)

1. Number of rooms
2. NASF
3. NASF/state NASF
4. Number of stations
5. NASF/station
6. Standard deviation of NASF/station

C. Detailed Room-Type (110-999) versus general Organizational-Unit Subject Field code. (1000-9000). Each cell contains the same information as Matrix 3.

D. Statewide HEGIS Matrix: General Room-Type versus general Organizational-Unit, contains only the number of rooms and the NASF in each cell followed by Non-Assignable listing.

E. "Data" Breakdown by type of school versus degree of graduate program" and "Statewide listing of area devoted to graduate use and percentage of state total NASF" are same format as on state level.

F. State wide date breakdown by construction decade versus type of construction. Each cell contains:

1. Number of buildings
2. Gross Area
3. NASF/Gross Area
4. Standard deviation of NASF/Gross Area
5. Percent renovated

G. "Condition versus type of construction" follows same format as above

H. "Condition versus last decade of renovation" follows same format as above

I. Series of matrices by decade of construction beginning 1908 shows condition versus types of construction and follows same format as above.

J. Summary matrix of I with all decades combined

K. Institutional codes (I-V) and public or private versus enrollment. Each cell contains:

1. Number of schools

2. NASF/student

3. Standard deviation of NASF/student

V. STATE SUMMARIES PART III - CORRELATIONS

A. Correlations:

1. Date of construction versus year to be demolished

2. Date of construction versus year to be demolished for non-renovated buildings

3. Date of construction versus year to be demolished for renovated buildings

4. Date of construction versus year to be renovated

5. Date of renovation versus year to be demolished

All correlation studies contain:

a. the number of points used,
b. the x-mean,
c. the y-mean,
d. correlation coefficient,
e. standard error of estimation, and
f. regression coefficient

B. Listing of percentage of buildings renovated by:

1. Type of construction
2. Condition
3. Percentage to be demolished

C. Listing of percentage of buildings non-renovated follows same format as above

D. The year to be demolished versus renovated and non-renovated

E. Correlations:

1. Gross Area-Academic, renovated past 15 years
2. Gross Area-Auxiliary, renovated past 15 years
3. Gross Area-Academic, to be razed next 15 years
4. Gross Area Auxiliary to be razed next 15 years

F. Financial studies: Correlations:

1. Gross Area versus cost/sq. ft., academic
2. Gross Area versus cost/sq. ft., auxiliary
3. Year to be constructed versus cost/sq. ft., academic
4. Year to be constructed versus cost/sq. ft., auxiliary

G. Gross Area per student studies:

1. Gross Area per student past 22 years, academic
2. Gross Area past 22 years, academic
3. Enrollment past 22 years

APPENDIX C.

DERIVED CORRELATION STATISTICS

Correlation no.	Description	Frequency	Average-X	Average-Y	Standard Deviation of X	Standard Deviation of Y	Standard Error of Estimation	Correlation Coefficient	Significance Level r≥0 (r≤0)	95% Confidence Interval	Regression Coefficient	Significance Level m≥0 (m≤0)	95% Confidence Interval
1	Yr Const. vs. Yr Demo, all	80	1896.4	1972.2	29.4	2.4	2.4	.115	.84	.326/-.107	.0093	.8+	.02727/-.00867
2	Same, for Non-renovated	49	1895.7	1971.5	33.9	2.0	2.0	.219	.93	.470/0.065	.0129	.9+	.02977/-.00397
3	Same, for Renovated	31	1897.4	1973.2	20.2	2.5	2.5	-.087	.67	.428/-.428	-.0109	.55+	.0363/-.0561
4	Yr Const. vs. Yr Renovated	384	1923.2	1960.9	18.8	7.7	7.6	.154	.99+	.249/.056	.0634	.995+	.1045/.0223
5	Yr Reno. vs. Yr Demolition	12	1959.0	1973.2	8.8	2.5	2.0	.601	.98+	.864/.042	.1742	.995+	.3355/.0129
6	Gr. Reno. last 15 yrs, Acad.	15	1961.0	368226	4.3	294,694	167,547	.823	.99	.939/.537	56,110	.9995+	79229/32992
7	Same, for Auxiliary	15	1961.0	334343	4.3	202,799	95.968	.861	.99	.960/.672	41,350	.9995+	54541/28159
8	Gr. Demo. next 15 yrs, Acad.	15	1976.0	64800	4.3	60,688	28,712	-.881	.99	-.960/-.670	12,370	.9995+	-8423-16317
9	Same, for Auxiliary	15	1976.0	20864	4.3	35,302	27,629	-.662	.99	-.860/-.586	-5086	.99+	-1283/-8889
10	Gross vs. cost per sq.ft., Acad	882	34,276	14.9	40155	15.6	15.2	.203	1.0	.264/.140	.000079	.9995+	.0001040/.0000539
11	Same, for Auxiliary	1013	22,908	11.5	32266	10.8	10.5	.241	1.0	.298/.183	.000081	.9995+	.0001040/.0000606
12	Const.vs.cost/sq ft,acad,1930-9	53	1934.5	8.5	3.3	6.4	6.4	.116	.79	.374/-.158	.2277	.75+	.7749/-.3209
13	Same, for 1940-9	52	1945.3	11.9	3.4	12.8	12.8	-.060	.66	-.328/.216	-.2265	.55+	1.4504/.1052
14	Same, for 1950-9	112	1955.4	22.1	2.9	21.1	20.7	.186	.97	.359/.000	1.3340	.975	2.668/.0000
15	Same, for 1960-9	193	1964.4	25.3	2.5	15.9	15.8	.108	.93	.246/-.035	.6970	.9+	1.6109/-.2169
16	Same, for Aux.,1930-9	51	1933.4	8.9	3.4	9.5	9.2	-.223	.95	.477/-.045	-.6514	.95+	.1285/-1.4313
17	Same, for Aux.,1940-9	46	1946.4	10.8	2.8	6.6	6.2	.331	.99	.568/.044	.7828	.975+	1.4504/.1052
18	Same, for Aux.,1950-9	95	1955.7	19.6	2.7	11.2	11.1	-.055	.70	.253/-.148	-.2235	.55+	.6202/-1.0672
19	Same, for Aux.,1960-9	231	1964.2	20.9	2.7	10.8	10.6	.173	.99	.295/.046	.6857	.995+	1.1944/.1772
20	Gross/Student last 22 years	18	1956.2	222.5	6.1	35.6	16.9	-.881	1.0	-.955/-.704	-5.1050	.9995+	-3.663/-6.546
21	Gross last 22 years	22	1957.5	28×10^6	6.3	4.21×10^6	1.2×10^6	.958	1.0	.983/.440	636,100	.9995+	724600/547600
22	Enrollment last 22 years	18	1956.2	129151	6.1	45,346	19,363	.904	1.0	.964/.756	6,669	.995+	10372/2966

APPENDIX D.

CORRELATION STUDIES GRAPHS

1 Gross Square Feet Academic Renovated Past 15 Years

2 Gross Square Feet Auxiliary Renovated Past 15 Years

3 Gross Area Academic To Be Razed Next 15 Years

4 Gross Area Auxiliary To Be Razed Next 15 Years

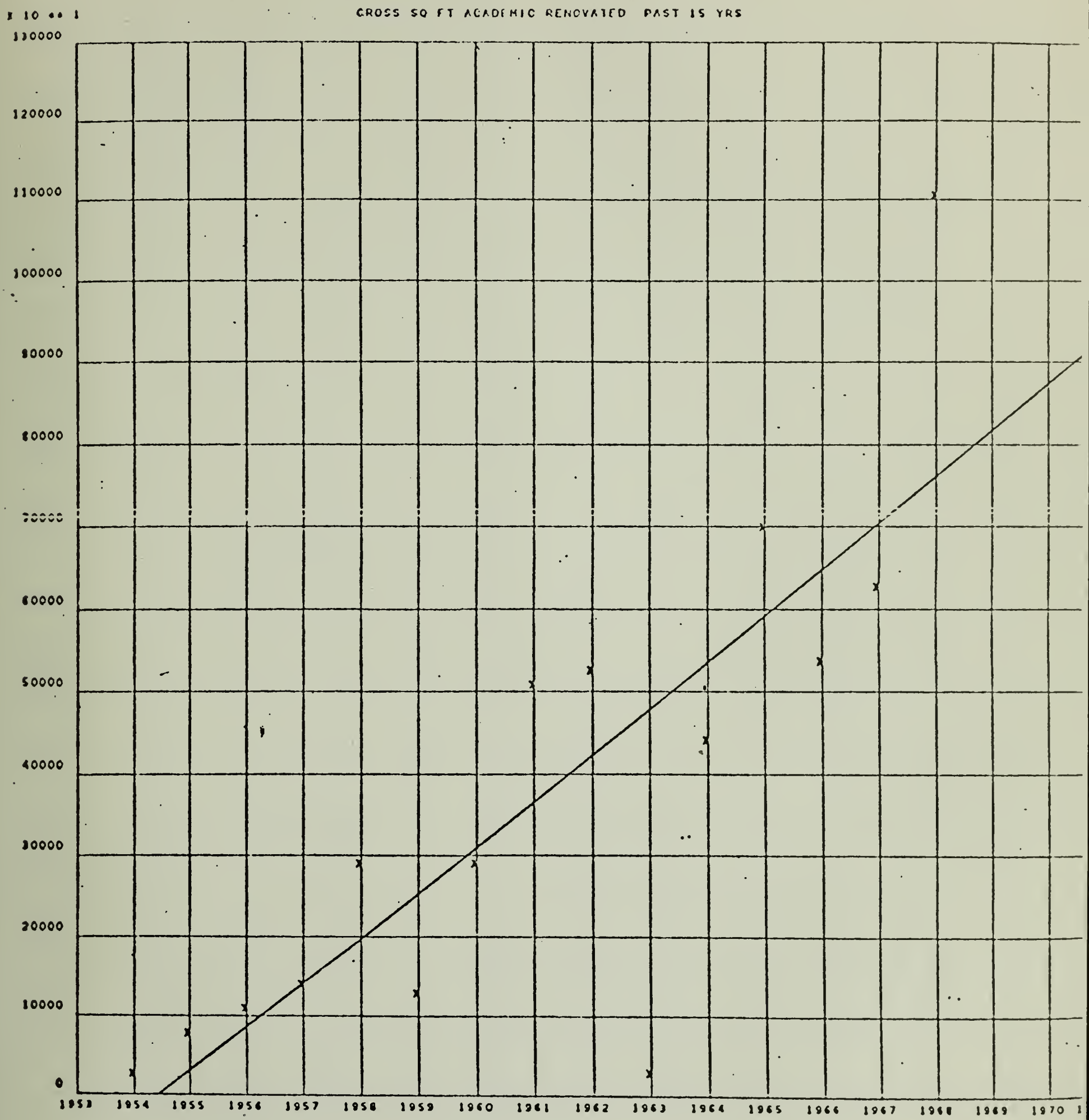
5 Year Constructed Versus Cost per Square Feet, Academic

6 Year Constructed Versus Cost per Square Feet, Auxiliary

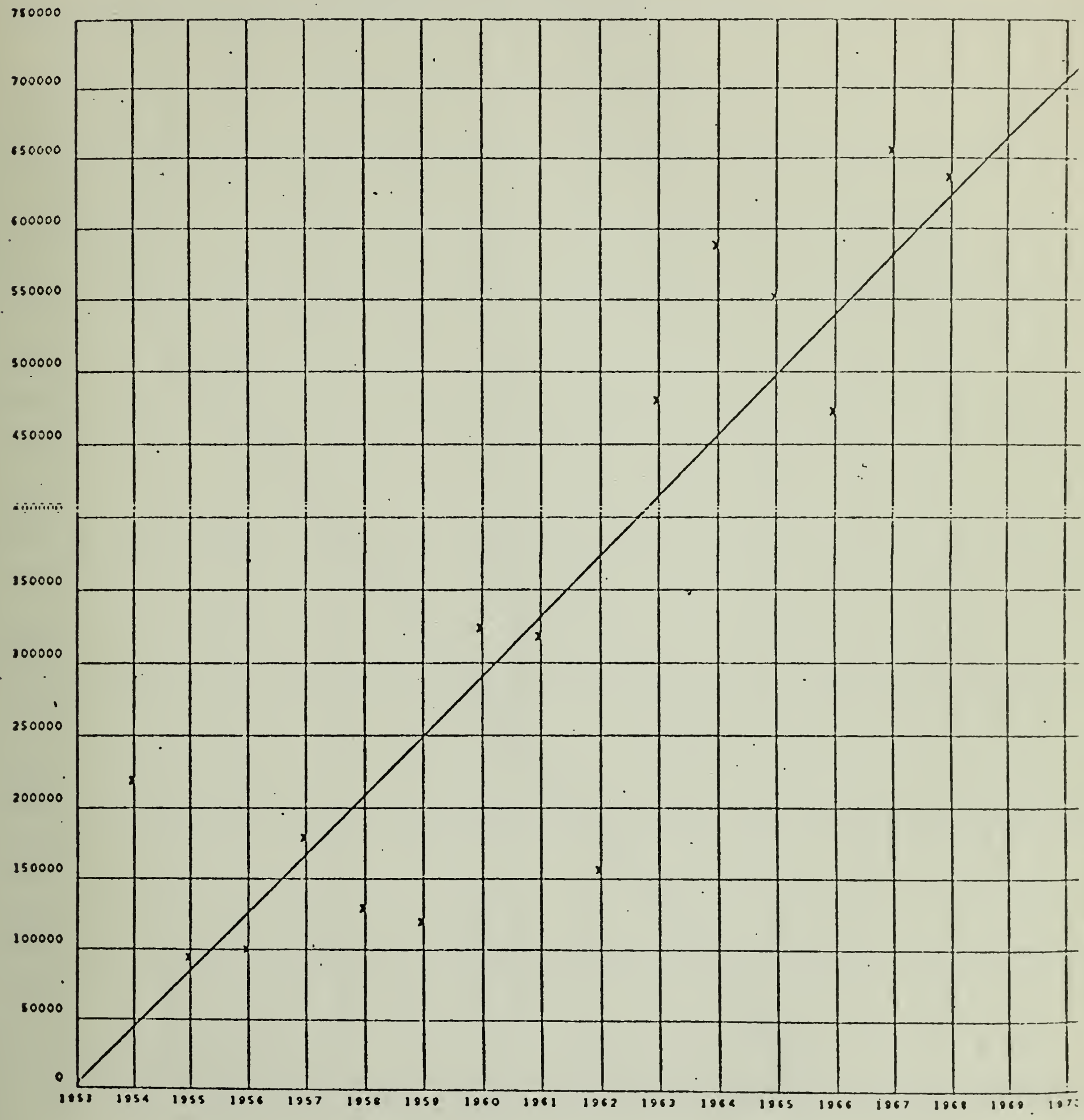
7 Gross Area, Past 22 Years, Academic

8 Enrollment, Past 22 Years

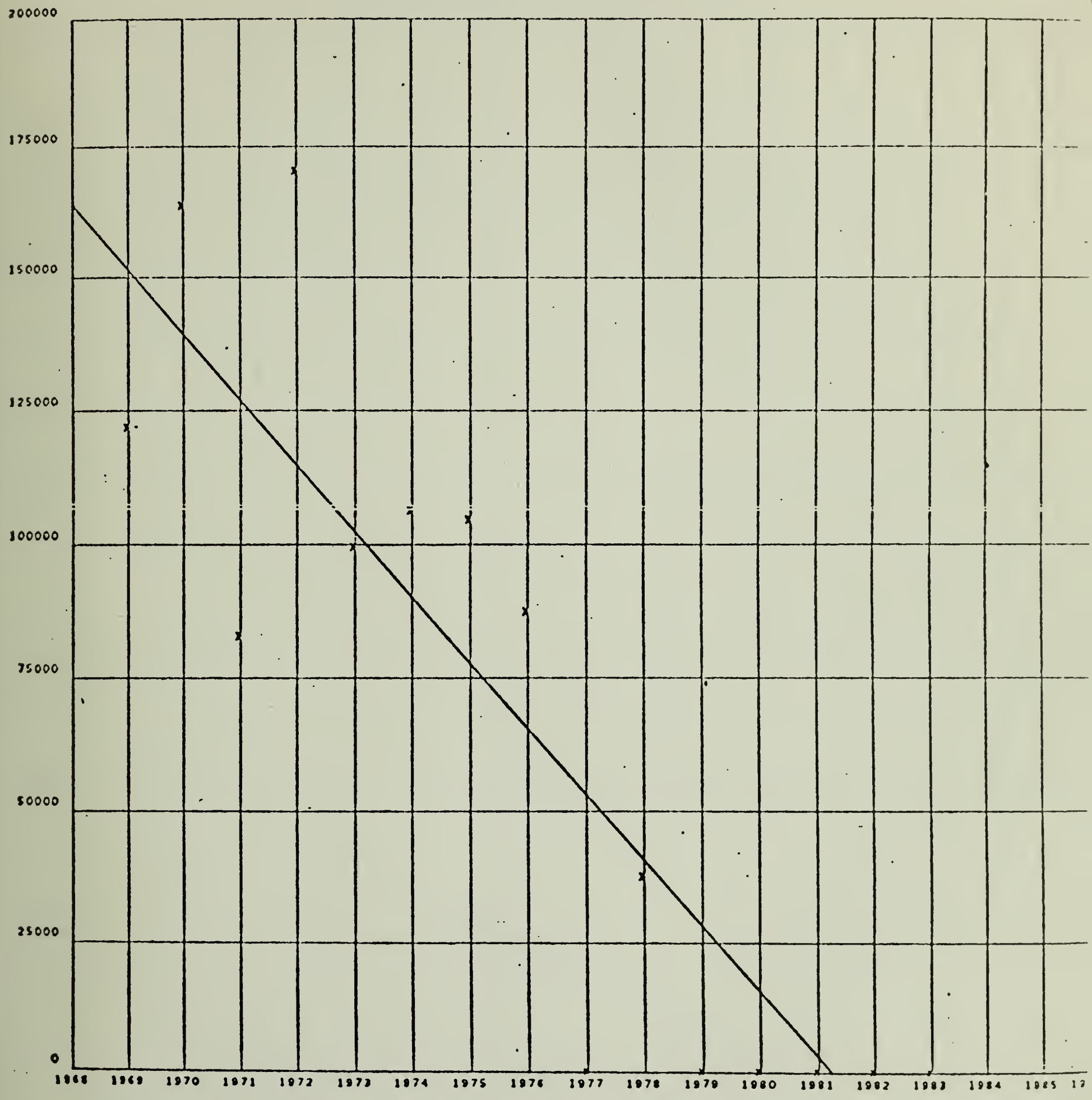
9 Gross Area per Student; Past 22 Years, Academic

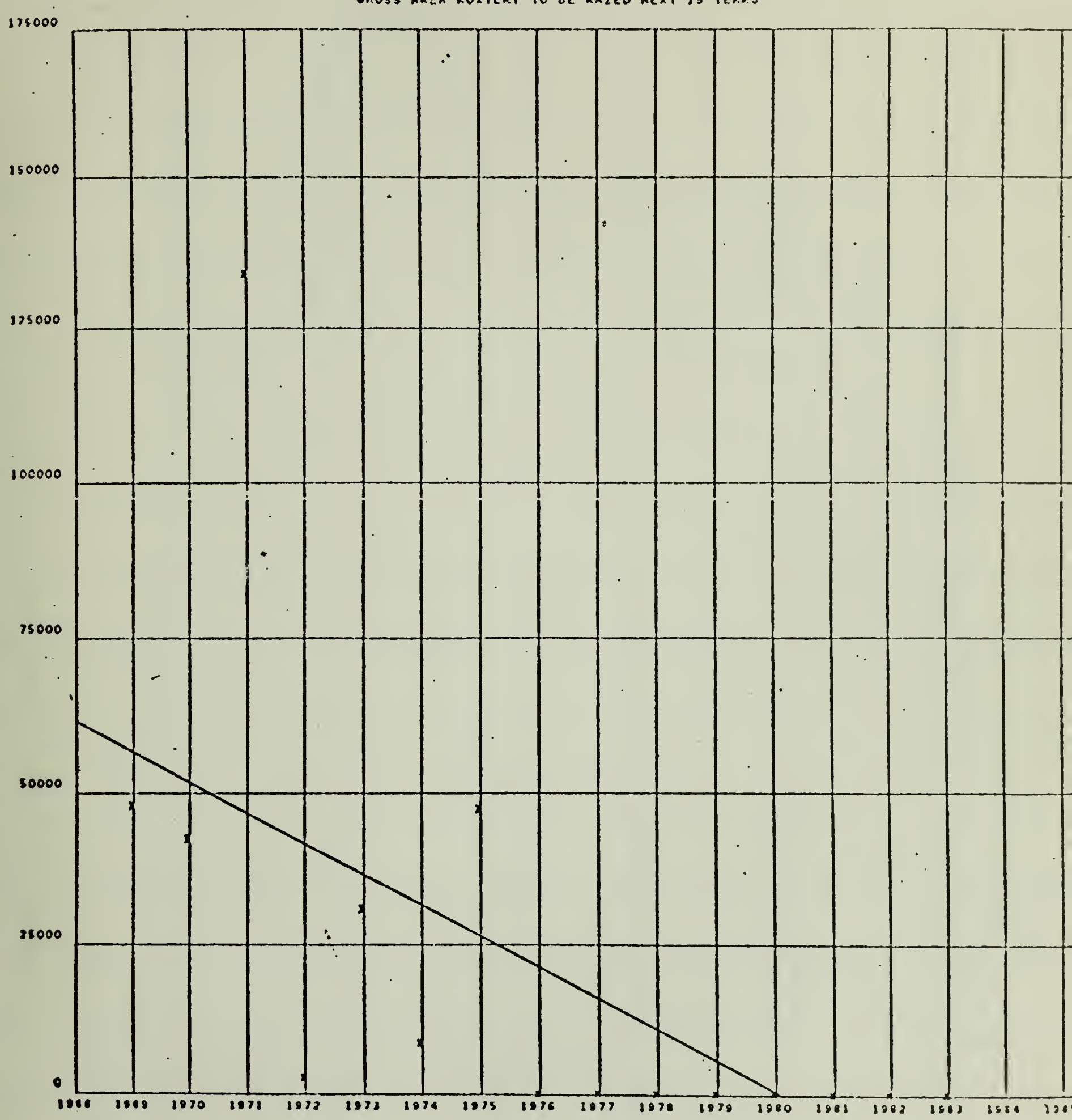

X 10 ** 1
GROSS SQ FT ACADEMIC RENOVATED PAST 15 YRS
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970

GROSS SQ FT AUXILIARY RENOVATED PAST 15 YRS

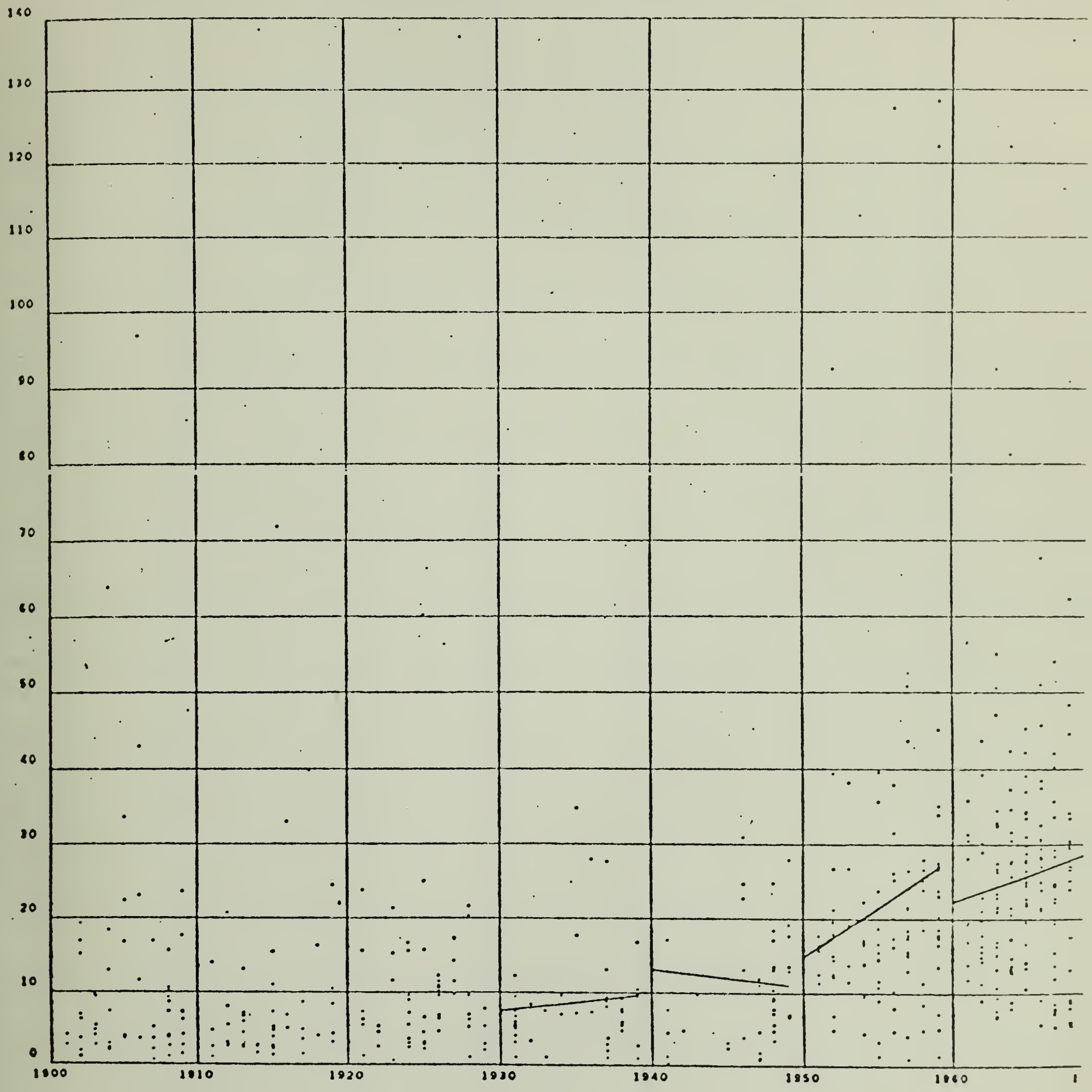


GROSS AREA ACADEMIC TO BE RAZED NEXT 15 YRS

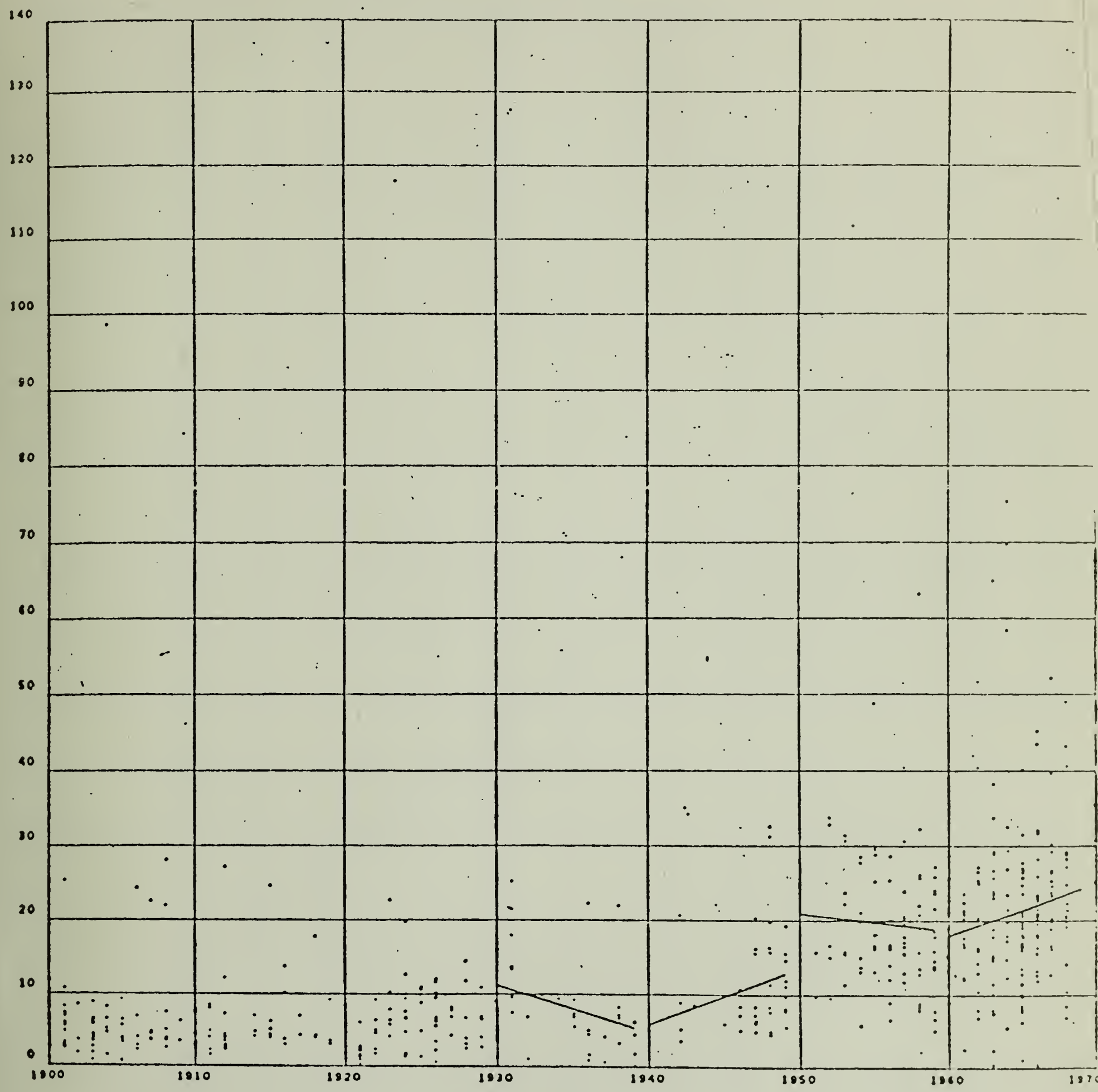


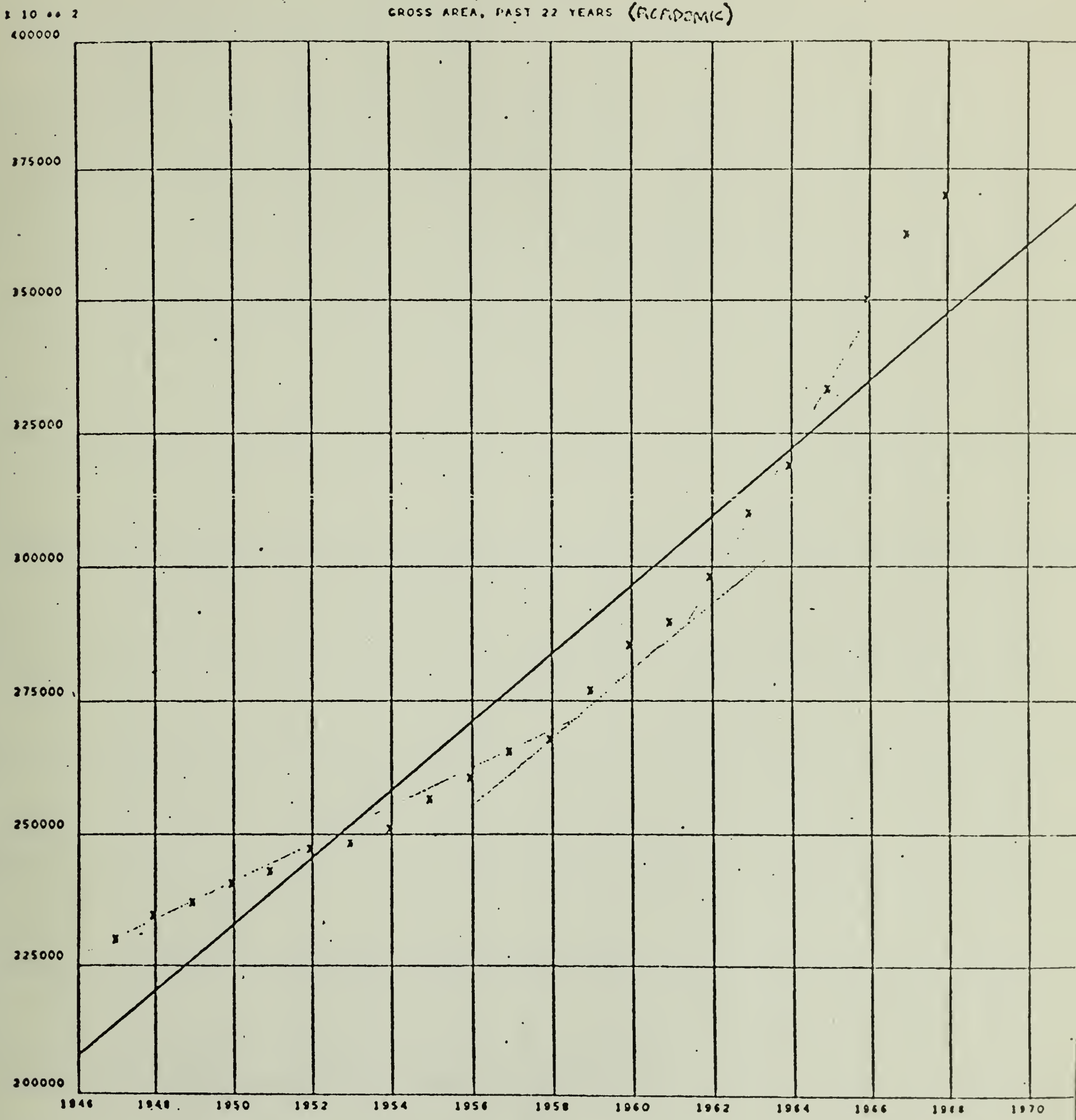

GROSS AREA AUXILRY TO BE RAZED NEXT 15 YEARS
175000
150000
125000
100000
75000
50000
25000
0
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984

YEAR CONSTRUCTED VS COST/SQ FT, ACADEMIC



YEAR CONSTRUCTED VS COST/SQ FT, AUXILIARY




X 10 ** 2
GROSS AREA, PAST 22 YEARS (ACADEMIC)
400000
375000
350000
325000
300000
275000
250000
225000
200000
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970

ENROLLMENT, PAST 22 YEARS